Network Systems Science & Advanced Computing

Biocomplexity Institute & Initiative

University of Virginia

Estimation of COVID-19 Impact in Virginia

January 5th, 2022

(data current to Jan 2nd – 4th)

Biocomplexity Institute Technical report: TR 2022-001

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About Us

- Biocomplexity Institute at the University of Virginia
  - Using big data and simulations to understand massively interactive systems and solve societal problems
- Over 20 years of crafting and analyzing infectious disease models
  - Pandemic response for Influenza, Ebola, Zika, and others

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Overview

- **Goal**: Understand impact of COVID-19 mitigations in Virginia
- **Approach:**
  - Calibrate explanatory mechanistic model to observed cases
  - Project based on scenarios for next 4 months
  - Consider a range of possible mitigation effects in "what-if" scenarios
- **Outcomes:**
  - Ill, Confirmed, Hospitalized, ICU, Ventilated, Death
  - Geographic spread over time, case counts, healthcare burdens

Key Takeaways

Projecting future cases precisely is impossible and unnecessary.
Even without perfect projections, we can confidently draw conclusions:

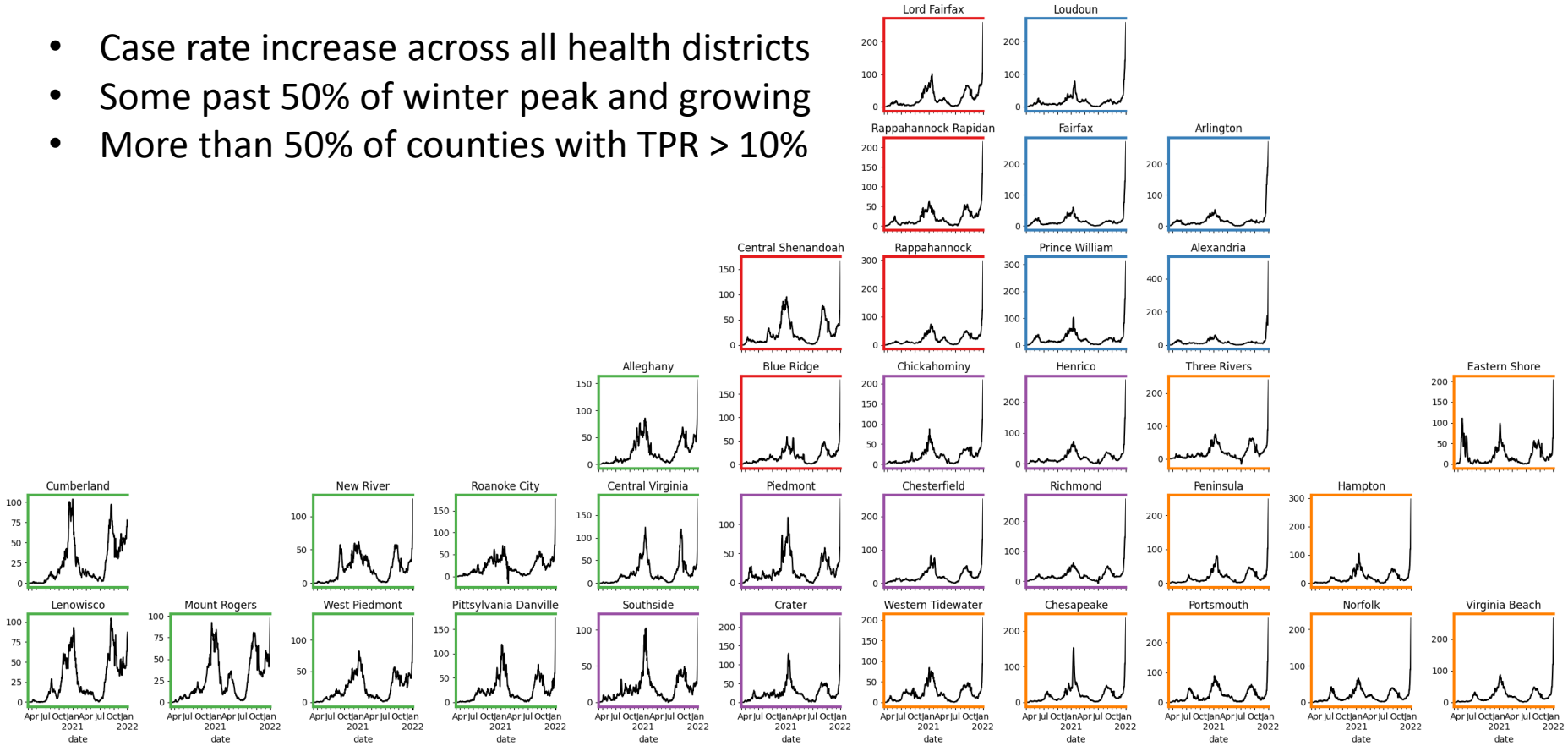
- **Case rates have accelerated to unprecedented levels throughout the commonwealth**
- VA 7-day mean daily case rate up to 155/100K from 79/100K; US is up to 144/100K (from 80/100K)
- Projections show a continued sharp rise in case-rates for several weeks:
  - Omicron is able to infect and transmit more between those with immunity from previous infections and vaccinations; hospitalizations will also rise despite reduced severity as case-rates out pace this reduction
  - Case ascertainment will drop as fewer infections cause severe disease, testing capacities are met, and at-home testing rises
- Recent model updates:
  - Overhauled model structure further refined to better capture different tiers of immunity and the immune evasion of the Omicron variant

The situation continues to change. Models continue to be updated regularly.

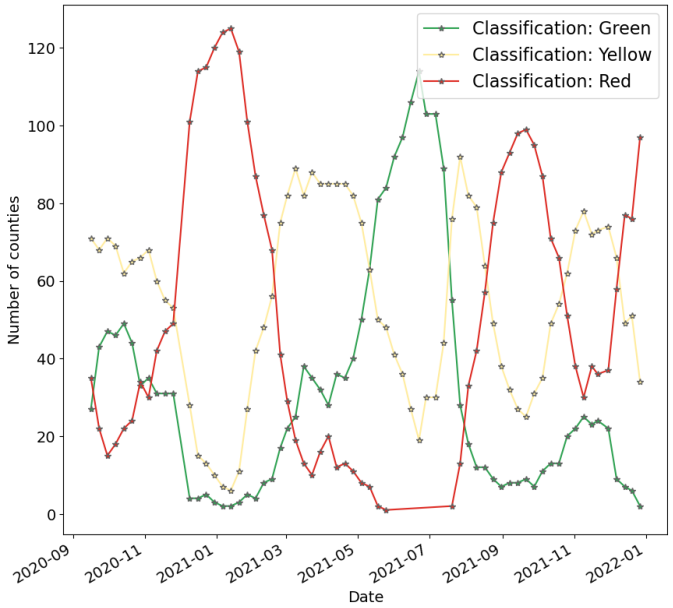
Situation Assessment

Case Rates (per 100k) and Test Positivity

- Case rate increase across all health districts
- Some past 50% of winter peak and growing
- More than 50% of counties with TPR > 10%



Data source: https://data.cms.gov/covid-19/covid-19-nursing-home-data



County level RT-PCR test positivity

Green: <5.0% (or <20 tests in past 14 days)

Yellow: 5.0%-10.0% (or <500 tests and <2000 tests/100k and >10% positivity over 14 days)

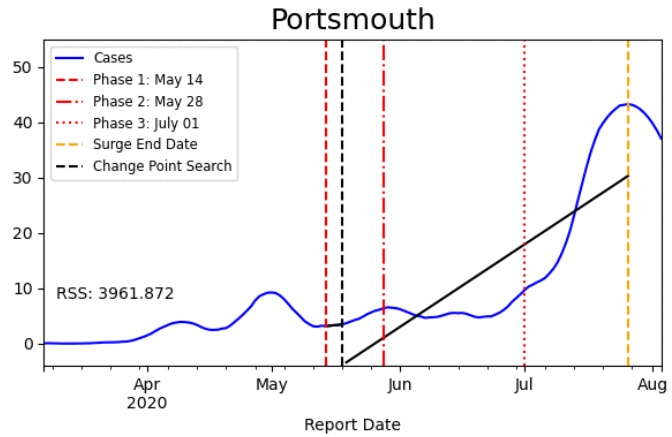
Red: >10.0% (and not "Green" or "Yellow")

District Trajectories

Goal: Define epochs of a Health District's COVID-19 incidence to characterize the current trajectory

Method: Find recent peak and use hockey stick fit to find inflection point afterwards, then use this period's slope to define the trajectory

Hockey stick fit

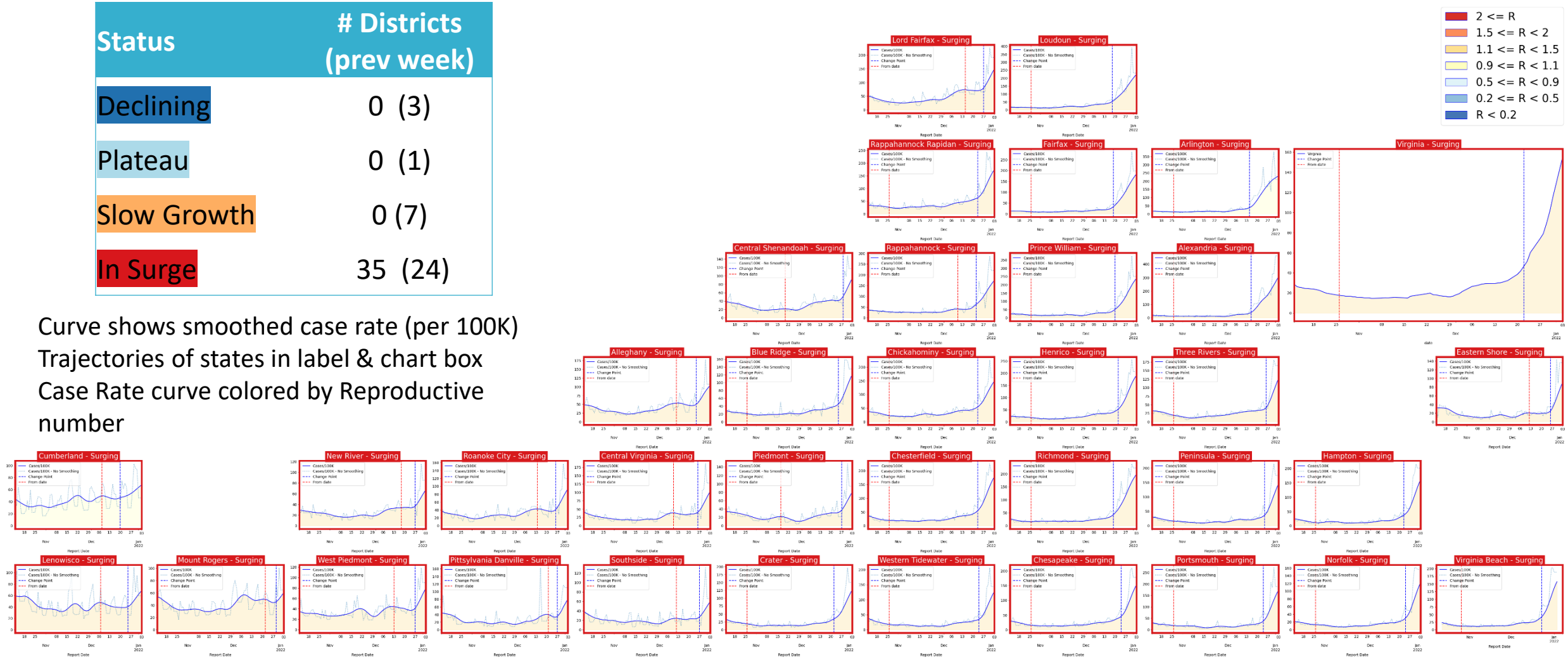


Trajectory	Description	Weekly Case Rate (per 100K) bounds	# Districts (prev week)
Declining	Sustained decreases following a recent peak	below -0.9	5 (1)
Plateau	Steady level with minimal trend up or down	above -0.9 and below 0.5	0 (0)
Slow Growth	Sustained growth not rapid enough to be considered a Surge	above 0.5 and below 2.5	9 (13)
In Surge	Currently experiencing sustained rapid and significant growth	2.5 or greater	21 (21)

District Trajectories – last 10 weeks

Status	# Districts (prev week)
Declining	0 (3)
Plateau	0 (1)
Slow Growth	0 (7)
In Surge	35 (24)

Curve shows smoothed case rate (per 100K)
Trajectories of states in label & chart box
Case Rate curve colored by Reproductive number



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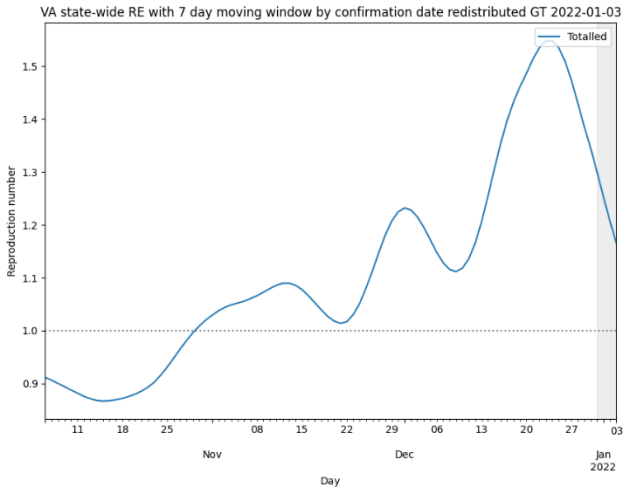
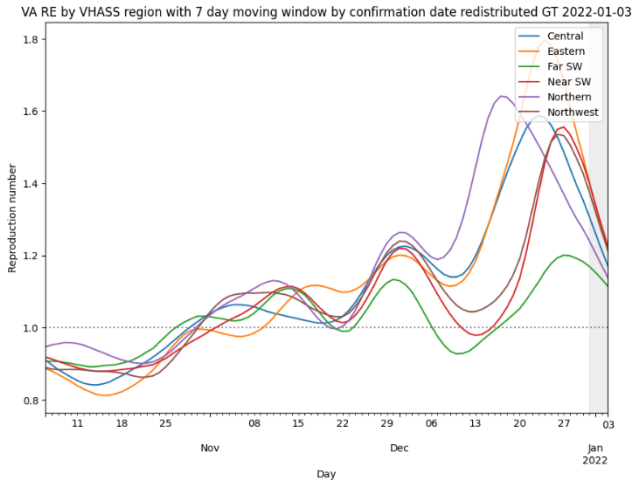
Estimating Daily Reproductive Number – Redistributed gap

Jan 3rd Estimates

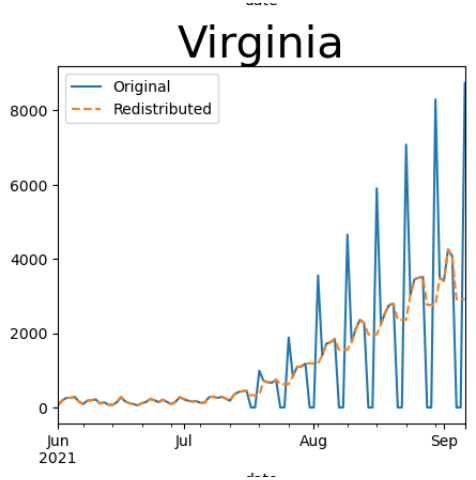
Region	Date Confirmed R_e	Date Confirmed Diff Last Week
State-wide	1.158	-0.316
Central	1.170	-0.316
Eastern	1.213	-0.469
Far SW	1.114	-0.087
Near SW	1.225	-0.331
Northern	1.138	-0.232
Northwest	1.213	-0.319





Skipping Weekend Reports & holidays biases estimates

Redistributed "big" report day to fill in gaps, and then estimate R from "smoothed" time series



Methodology

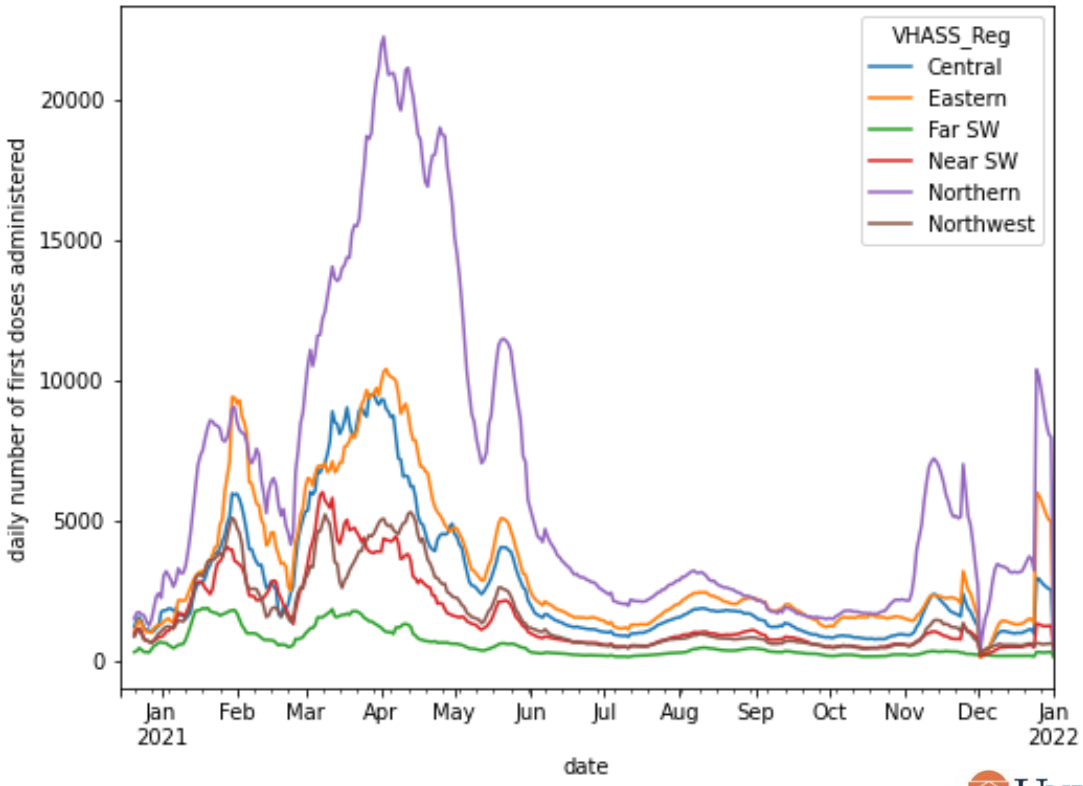
- Wallinga-Teunis method (EpiEstim[1]) for cases by **confirmation date**
- Serial interval: updated to discrete distribution from observations (mean=4.3, Flaxman et al, Nature 2020)
- Using Confirmation date since due to increasingly unstable estimates from onset date due to backfill

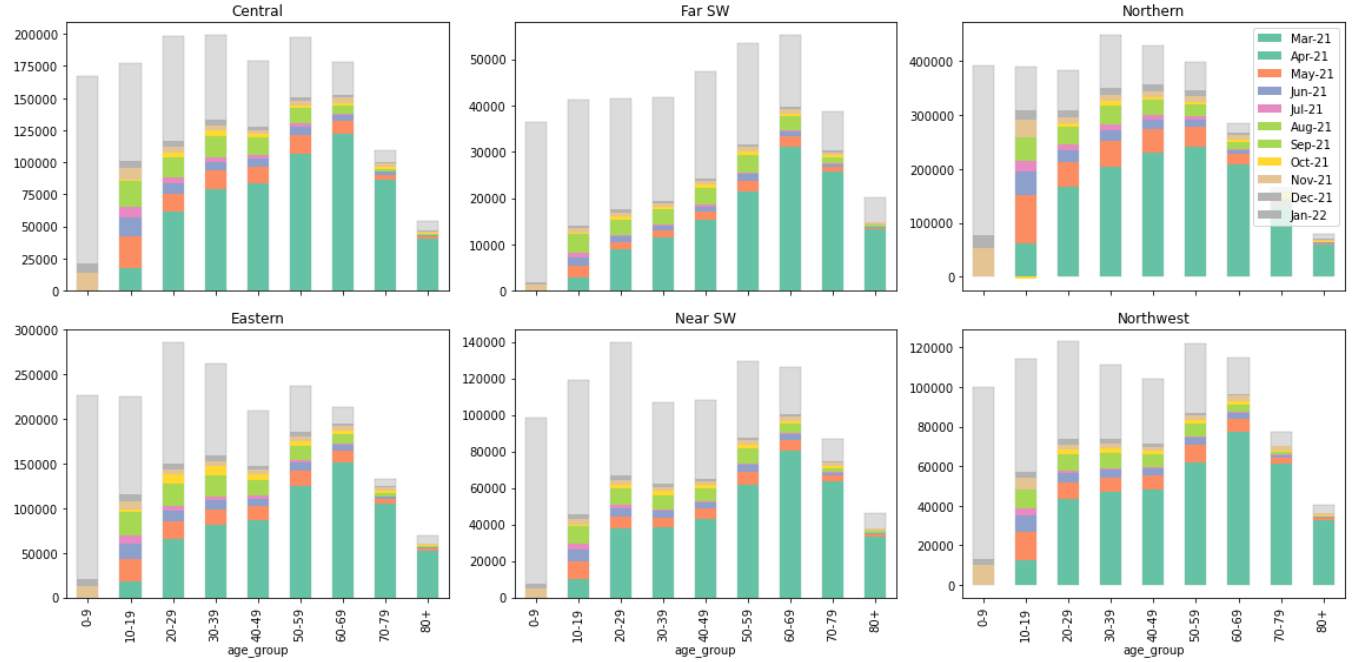
1. Anne Cori, Neil M. Ferguson, Christophe Fraser, Simon Cauchemez. A New Framework and Software to Estimate Time-Varying Reproduction Numbers During Epidemics. American Journal of Epidemiology, Volume 178, Issue 9, 1 November 2013, Pages 1505–1512, https://doi.org/10.1093/aje/kwt133

Vaccination Administration of First Doses

Regional Vaccine courses initiated per day (% eligible):

- Uptick with 5-11 year old eligibility but interrupted by holidays etc.
- Age-specific proportions of population vaccinated show recent progress in younger ages





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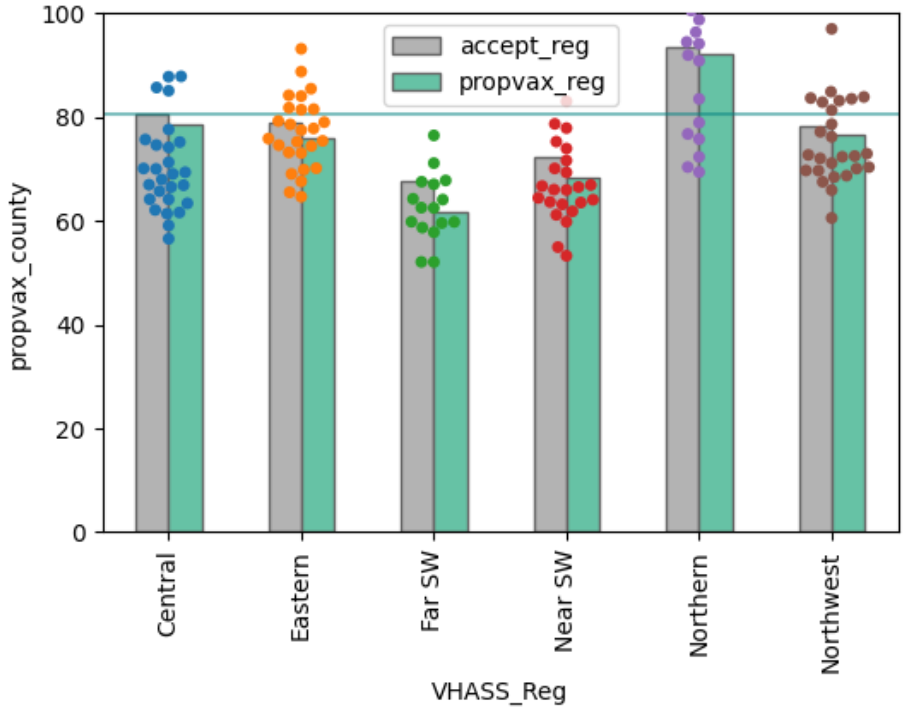
Vaccination Acceptance by Region

Corrections to surveys:

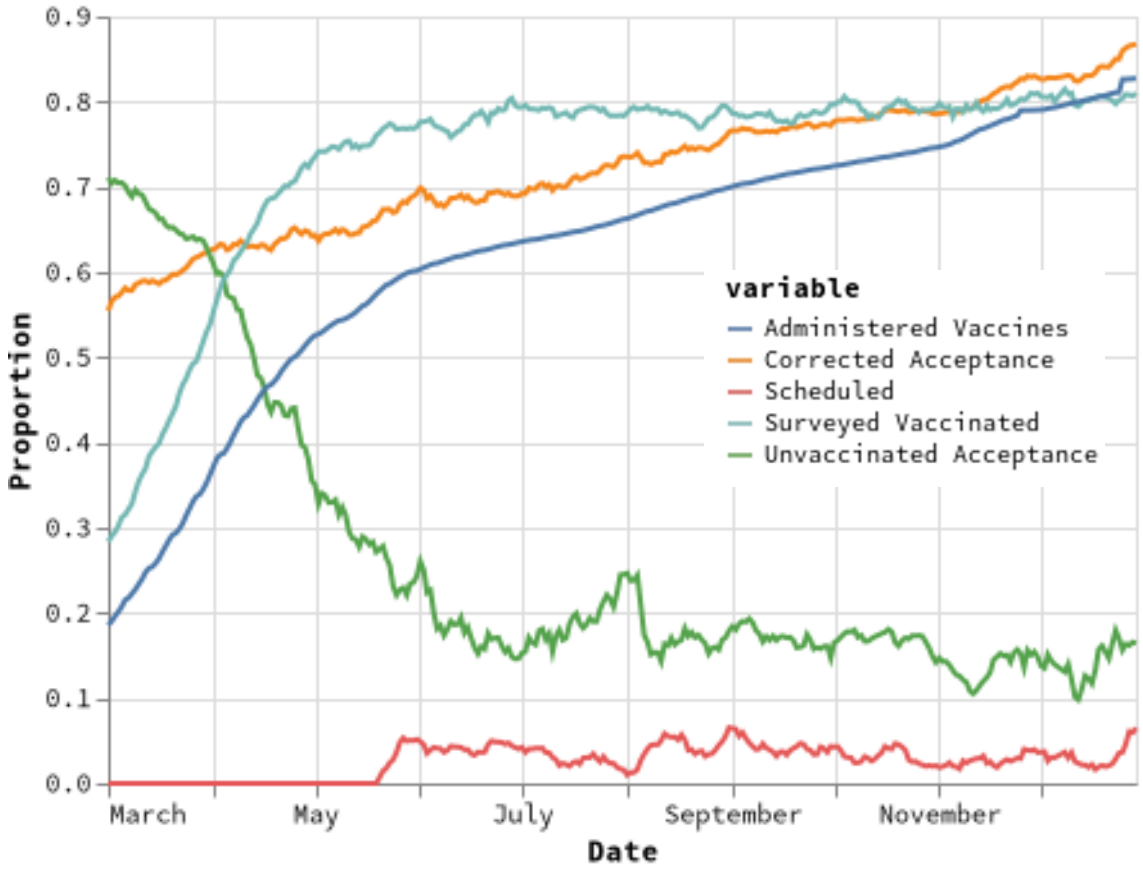
- Facebook administered survey is timely and broad, but biased by who accesses Facebook and answers the survey
- Correction approach:
  - Calculate an over-reporting fraction based on reported vaccinations compared to VDH administration data
  - Cross-validate coarse corrections against HPS survey at the state level and corrected in same manner

Region	COVIDcast accepting corrected	VDH proportion pop vaccinated
Central	86%	80%
Eastern	85%	79%
Far SW	70%	63%
Near SW	74%	70%
Northern	96%	95%
Northwest	82%	78%
Virginia	**87%**	**83%**



Grey Bar: Survey measured and corrected acceptance
Green Bar: Proportion of eligible population administered a vaccine
Dots: Proportion administered at least one dose for each county

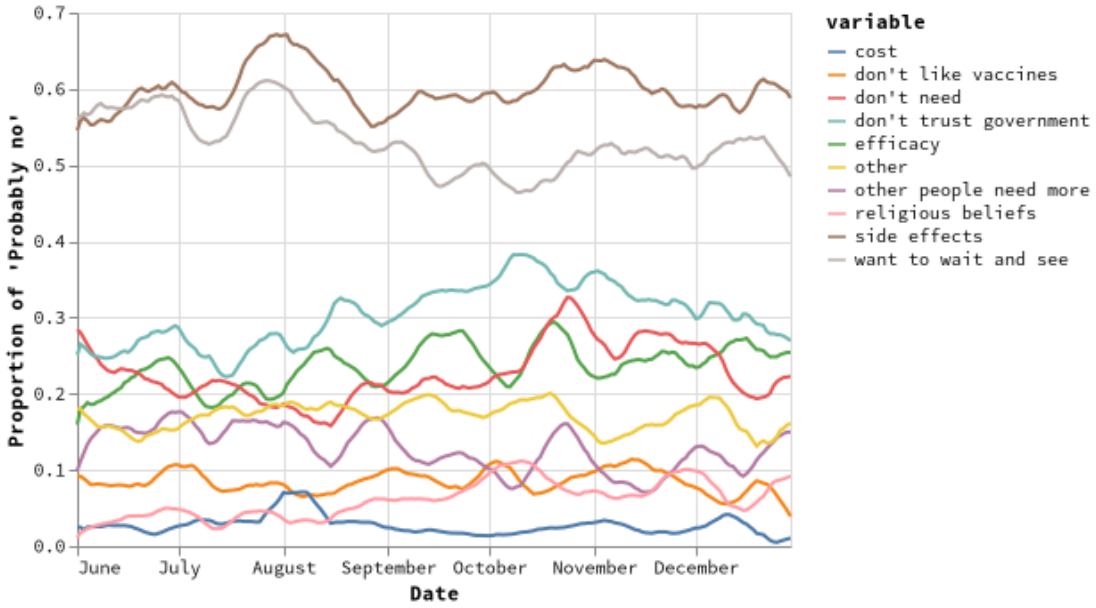
Vaccine Acceptance Components over Time



Vaccine Acceptance adjusted to include scheduled appointments

- Steady rise in acceptance over the past couple months
- Unvaccinated Acceptance shows ~20% of those who are unvaccinated are definitely or probably willing to be vaccinated
- Scheduled appointments for vaccination have increased through August but seem to be leveling off

Reasons among those that are Probably not going to Vaccinate

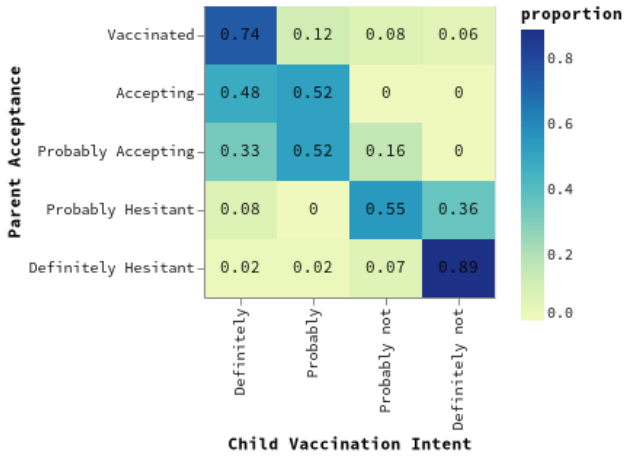


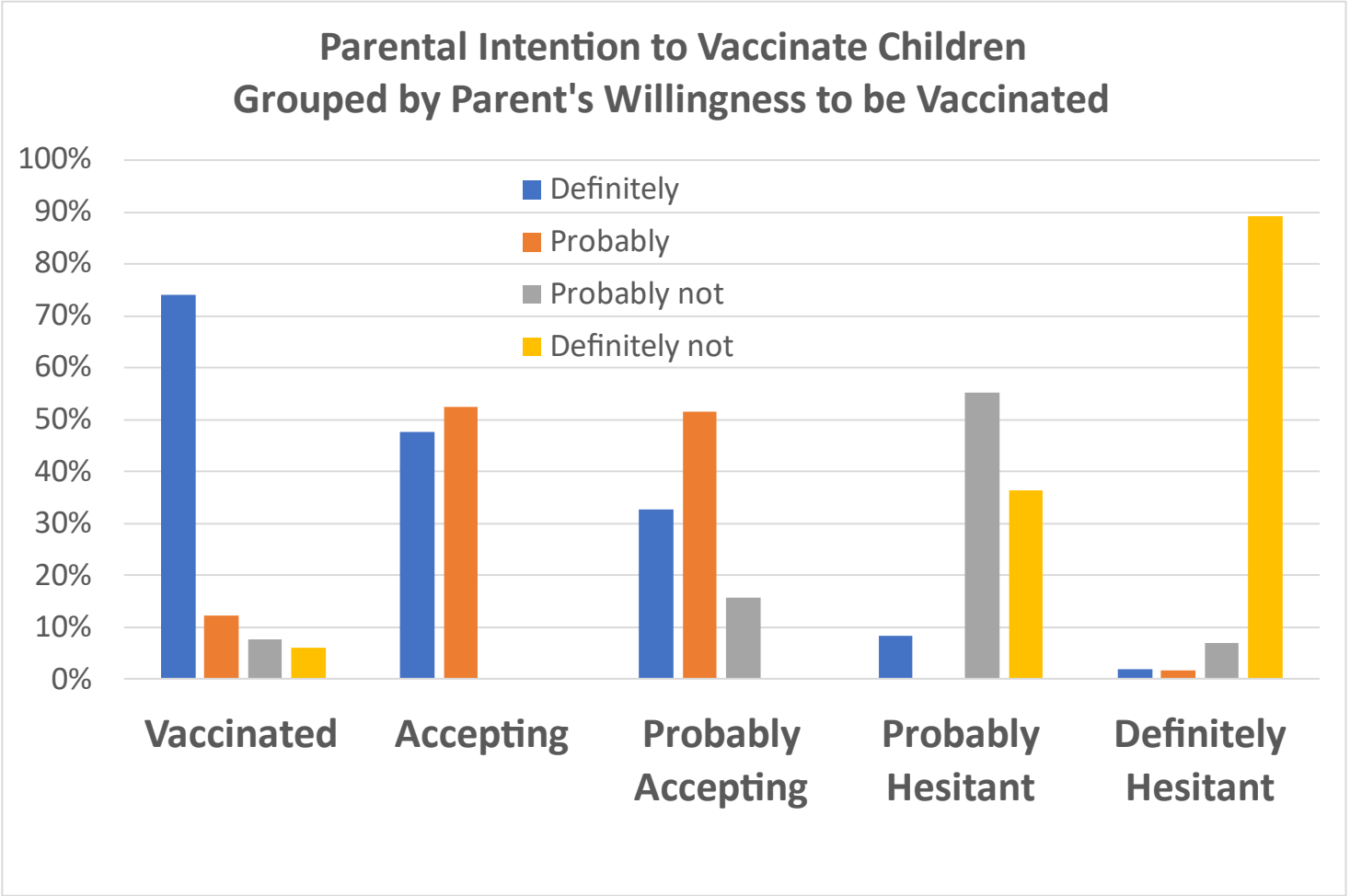
Data Source: https://covidcast.cmu.edu

Parental Intention to Vaccinate Children

Parental Intention to Vaccinate Children lower than overall Acceptance

- Most willing (vaccinated) remain at ~70% definitely intending to vaccinate kids
- Intention strongly biased by the willingness of the parent, and skews towards unwillingness to vaccinate



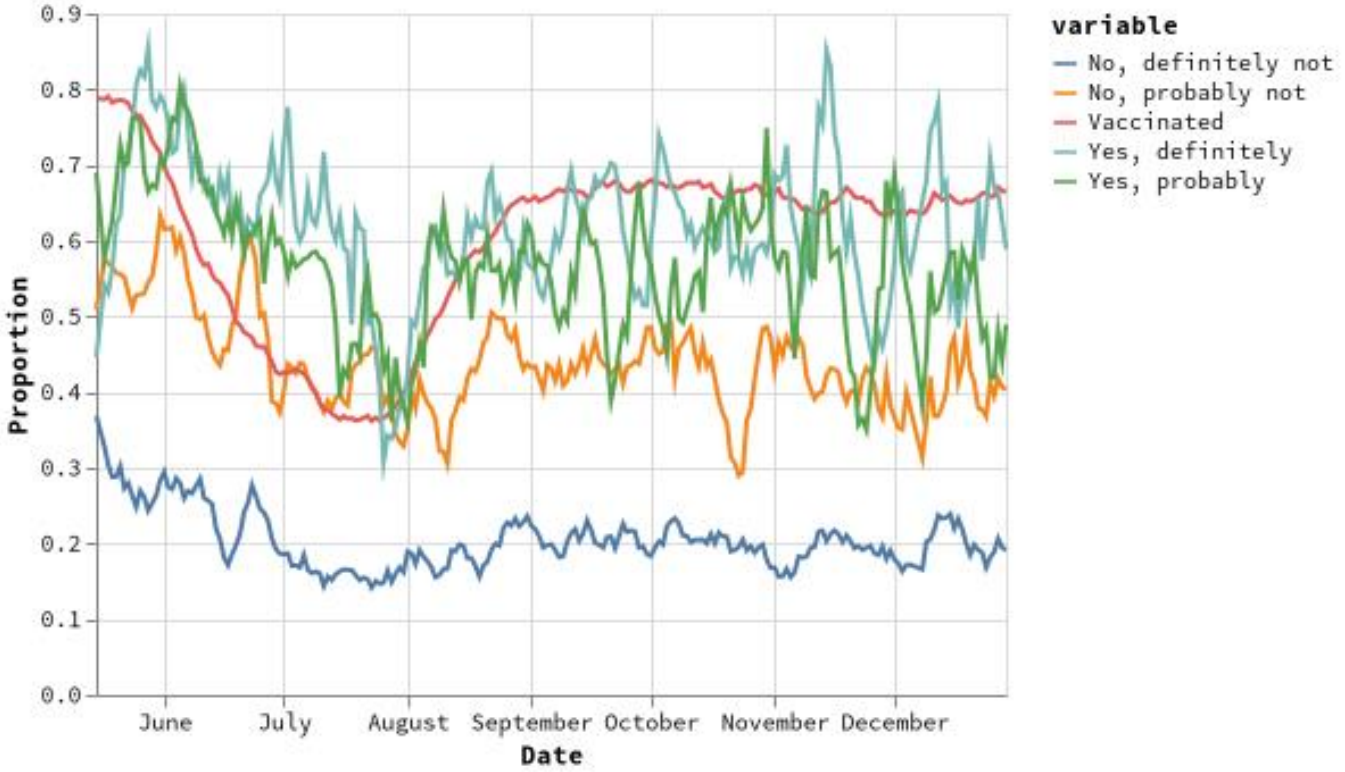


Data Source: https://covidcast.cmu.edu

Mask Usage Stalls

Self-reported mask usage has increased slightly to ~64% (mid 60s in previous months)

- US and VA experienced similar small ticks up
- Mask wearing remains lower amongst unvaccinated especially among least willing to be vaccinated



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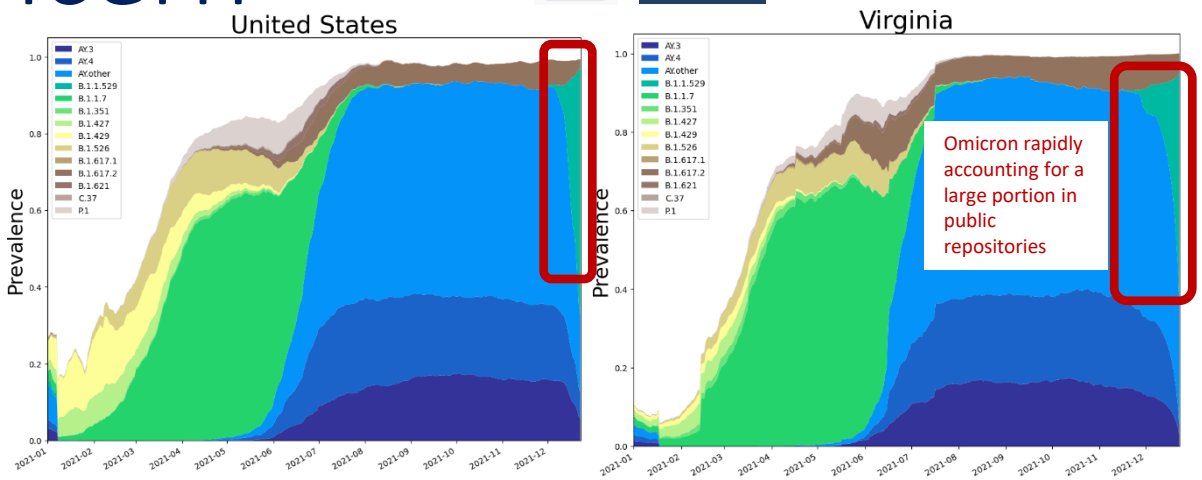
Data Source: https://covidcast.cmu.edu

SARS-CoV2 Variants of Concern

Emerging new variants will alter the future trajectories of pandemic and have implications for future control

- Emerging variants can:
  - Increase transmissibility
  - Increase severity (more hospitalizations and/or deaths)
  - Limit immunity provided by prior infection and vaccinations
- Genomic surveillance remains very limited
  - Challenges ability to estimate impact in US to date and estimation of arrival and potential impact in future

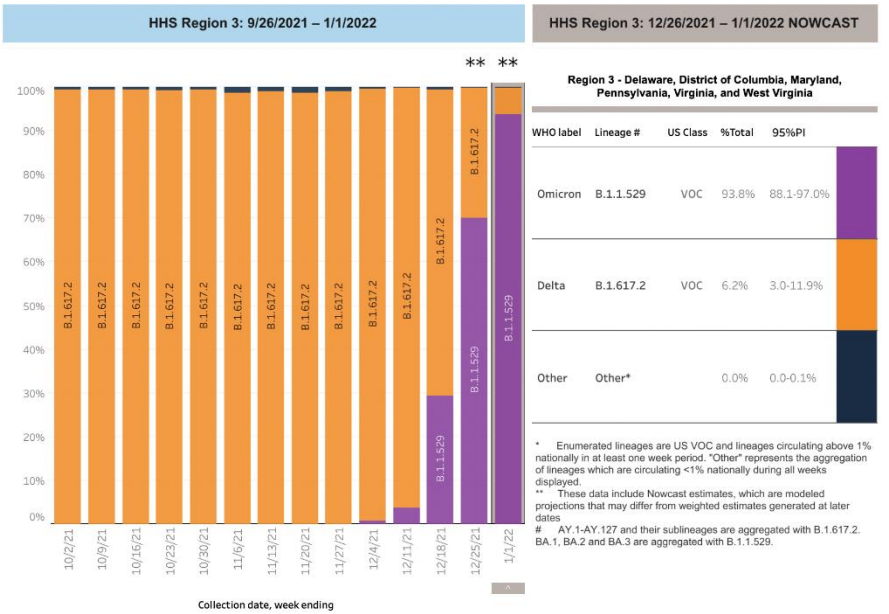


WHO label	Pango lineage*	GISAID clade	Nextstrain clade	Additional amino acid changes monitored*	Earliest documented samples	Date of designation
Alpha	B.1.1.7	GRY	20I (V1)	+S:484K +S:452R	United Kingdom, Sep-2020	18-Dec-2020
Beta	B.1.351	GH/501Y.V2	20H (V2)	+S:L18F	South Africa, May-2020	18-Dec-2020
Gamma	P.1	GR/501Y.V3	20J (V3)	+S:681H	Brazil, Nov-2020	11-Jan-2021
Delta	B.1.617.2	G/478K.V1	21A, 21I, 21J	+S:417N +S:484K	India, Oct-2020	VOI: 4-Apr-2021 VOC: 11-May-2021
Omicron*	B.1.1.529	GRA	21K, 21L	+R346K	Multiple countries, Nov-2021	VUM: 24-Nov-2021 VOC: 26-Nov-2021

World Health Organization [WHO](#)

Omicron Prevalence SIGNIFICANTLY revised again from previous weeks

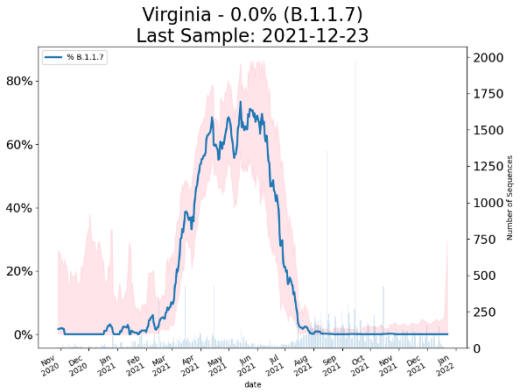
Original estimate of ~50% prevalence during week ending 12-25 supported



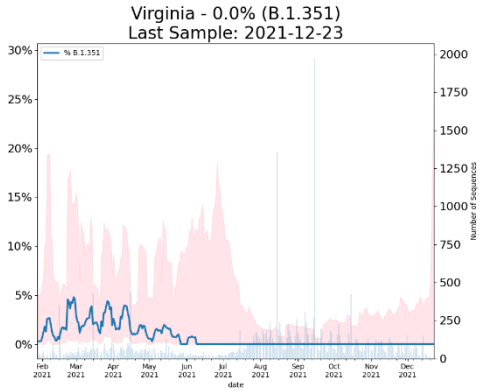
CDC [CDC Variant Tracking](#)

SARS-CoV2 Variants of Concern

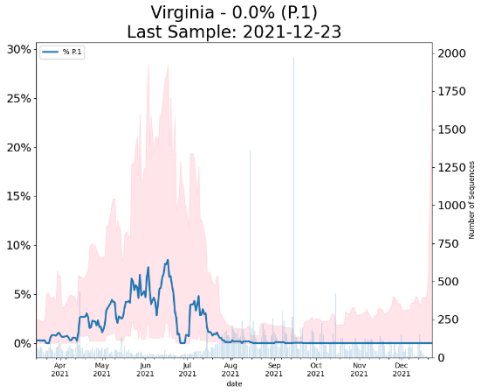
Alpha α - Lineage B.1.1.7



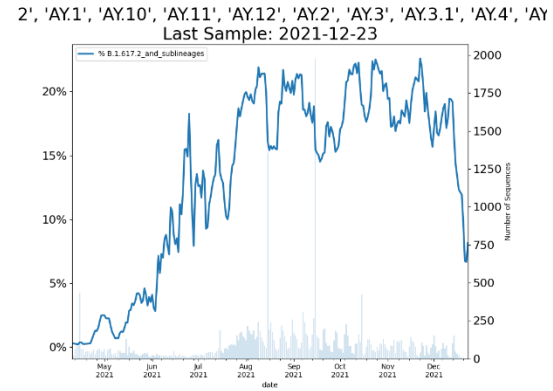
Beta β - Lineage B.1.351



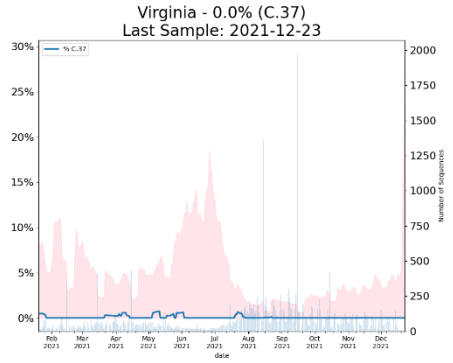
Gamma γ - Lineage P.1



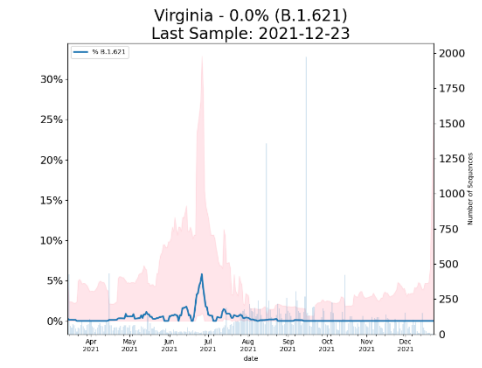
Delta δ - Lineage B.1.617.2



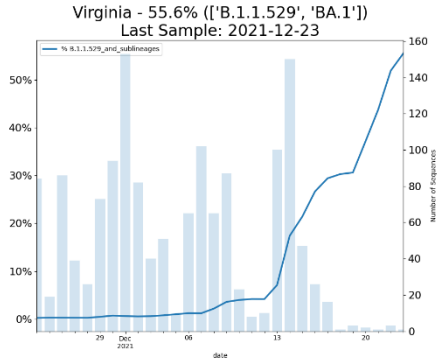
Lambda λ - Lineage C.37

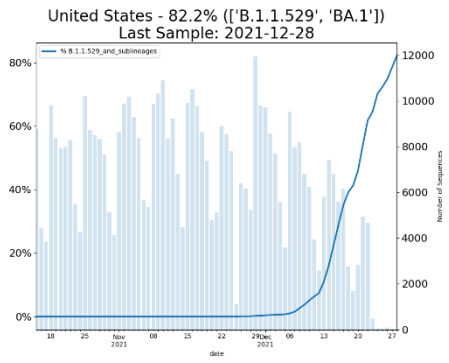


Mu μ - Lineage B.1.621



Omicron ο - Lineage B.1.1.529





Omicron

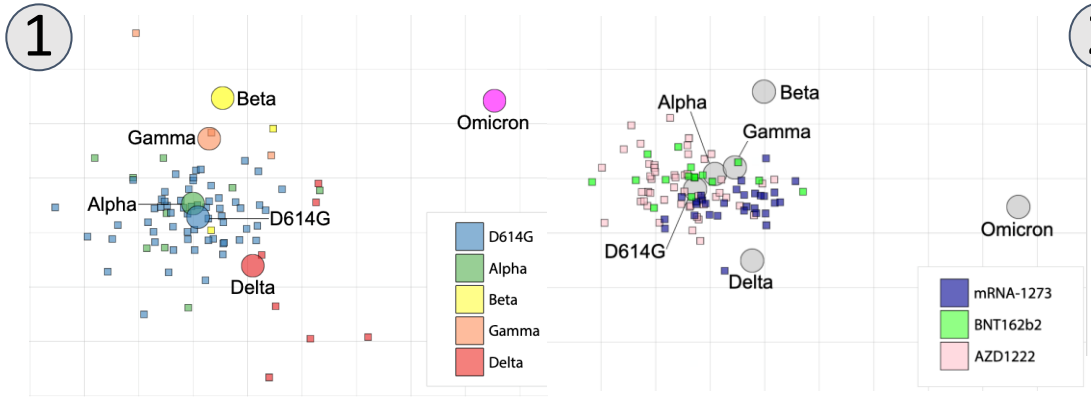
1. Omicron is unique compared to other VOCs in its antigenic "class" (MedArxiv)

2. Studies from South Africa, the UK, and Canada show reduced risk of hospitalization and death in matched control studies compared to Delta. Vaccine effectiveness against symptomatic disease is significantly lower than with Delta and wanes faster.

3. Danish study observed no significant difference between the SAR of Omicron versus Delta among unvaccinated household members

4. This Imperial College London study shows Omicron replicates rapidly in human primary airway cultures, more so even than the previously dominant variant of concern, Delta.

1



Researchers at University of Amsterdam collected and analysed a unique set of serum samples from 51 COVID-19 patients with a PCR-confirmed primary SARS-CoV-2 infection **who did not receive COVID -19 vaccinations** using multidimensional scaling. In this map, homologous sera tend to cluster around the infecting strain, reflecting that homologous neutralization is dominant. (1 unit = 2 -fold change in neutralization titre). This procedure was also extended to vaccinated individual neutralization data. **For influenza viruses, variants are considered to be antigenically similar in case of antigenic distances below 3 antigenic units (an 8-fold change in neutralization titre), and different when above this threshold. The distance between this antigenic cluster and Omicron is more than 5 antigenic units (>32 -fold change in neutralization).** One caveat is that it is unclear whether 2-fold changes in pseudovirus neutralization titres are directly comparable to 2- fold changes in hemagglutination inhibition assay titres used to characterize influenza viruses.
https://www.medrxiv.org/content/10.1101/2022.01.03.21268582v1

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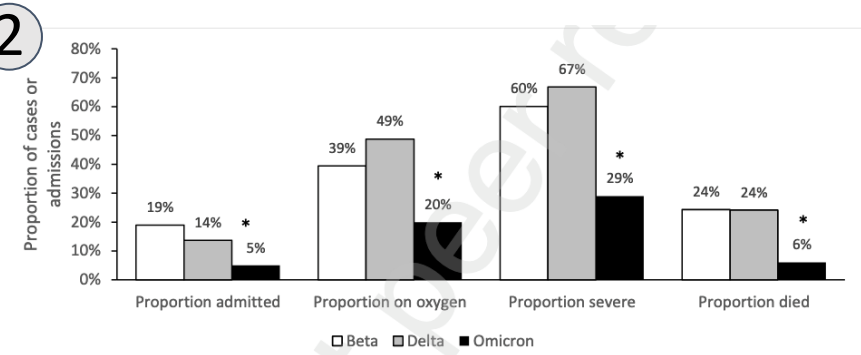


Table 5: Hazard ratios (HR) against hospitalisation with Omicron and Delta (all brands combined) (CI=Confidence interval)

		HR against hospitalisation (95% CI)	
Dose	**Interval after dose**	**Omicron**	**Delta**
1	4+ weeks	0.65 (0.30-1.42)	0.27 (0.2-0.37)
2	2-24 weeks	0.33 (0.21-0.55)	0.1 (0.09-0.13)
2	25+ weeks	0.49 (0.30-0.81)	0.15 (0.13-0.18)
3	2+ weeks	0.32 (0.18-0.58)	0.11 (0.09-0.14)

Table 6: Vaccine effectiveness against hospitalisation for Omicron (all vaccine brands combined). OR = odds ratio, HR = hazard ratio, VE = vaccine effectiveness (CI=Confidence interval)

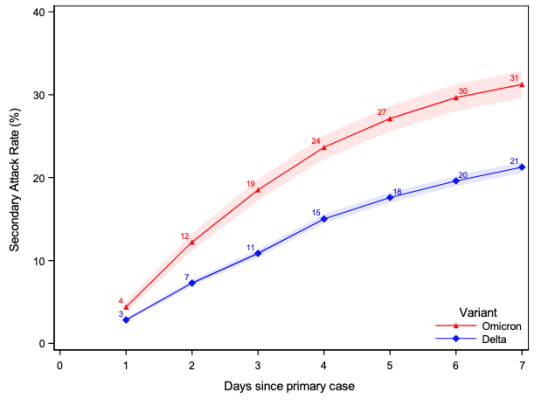
Dose	Interval after dose	OR against symptomatic disease (95% CI)	HR against hospitalisation (95% CI)	VE against hospitalisation (95% CI)
1	4+ weeks	0.74 (0.70-0.77)	0.65 (0.30-1.42)	52% (-5-78)
2	2-24 weeks	0.82 (0.80-0.84)	0.33 (0.21-0.55)	72% (55-83)
2	25+ weeks	0.98 (0.95-1.00)	0.49 (0.30-0.81)	52% (21-71)
3	2+ weeks	0.37 (0.36-0.38)	0.32 (0.18-0.58)	88% (78-93)

3

	Unvaccinated	Fully vaccinated	Booster-vaccinated
Omicron households	1.17 (0.99-1.38)	2.61 (2.34-2.90)	3.66 (2.65-5.05)
Delta households	ref (.)	ref (.)	ref (.)
Number of observations	27,874	27,874	27,874
Number of households	11,937	11,937	11,937

Among 11,937 households (2,225 with the Omicron VOC), this Danish study identified 6,397 secondary infections during a 1-7 day follow-up period. Comparing households infected with the Omicron to Delta VOC, we found an 1.17 (95%-CI: 0.99-1.38) times higher SAR for un-vaccinated, 2.61 times (95%-CI: 2.34-2.90) higher for fully vaccinated and 3.66 (95%-CI: 2.65-5.05) times higher for booster-vaccinated individuals, demonstrating strong evidence of immune evasiveness of the Omicron VOC.
https://www.medrxiv.org/content/10.1101/2021.12.27.21268278v1

(b) Probability of testing positive



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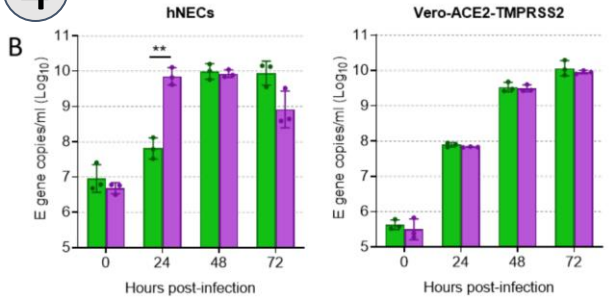
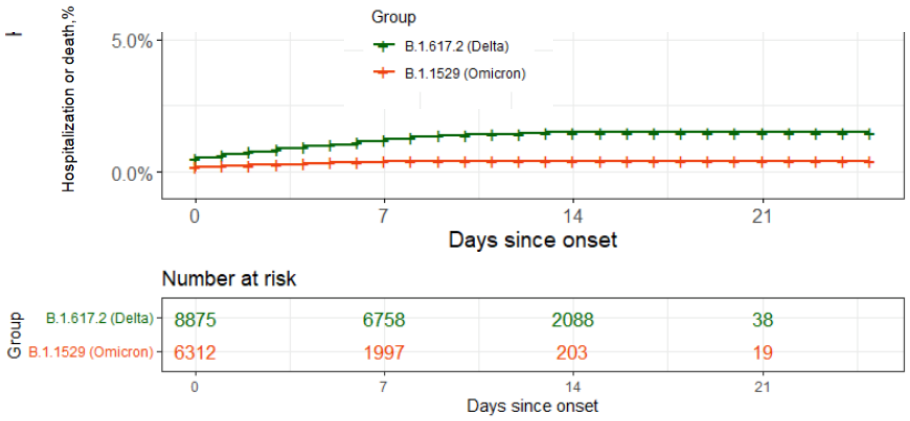


Growth advantage assay inoculating an equal amount of each variant (Omicron Purple; Delta Green) into the wells of human nasal epithelial cultures (hNECs), Vero-ATs (cancer lung cells). In hNECs Omicron showed a large early replication advantage, yielding viral titres ~100-fold higher than Delta by 24 hours post-infection (decrease at 72h was due to cell death).
https://twitter.com/PeacockFlu/status/1477227925124616192



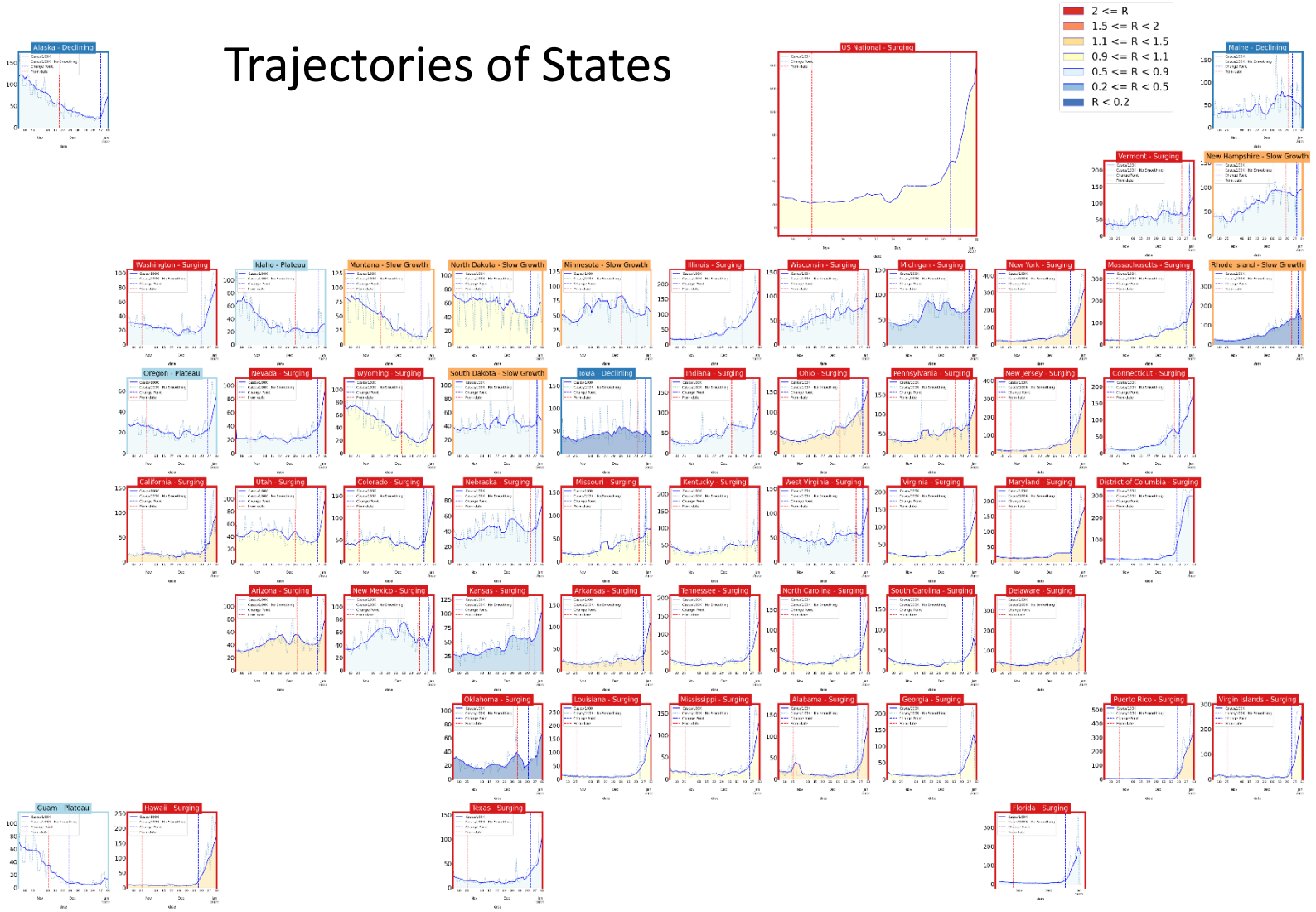
https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3996320
https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1044481/Technical-Briefing-31-Dec-2021-Omicron_severity_update.pdf
https://www.medrxiv.org/content/10.1101/2021.12.24.21268382v1.full.pdf

United States Overall

- Most of nation is in Surge
- Growth has spread from Northeast into Midwest and South

Status	# States
Declining	3
Plateau	3
Slow Growth	6
In Surge	42

Trajectories of States



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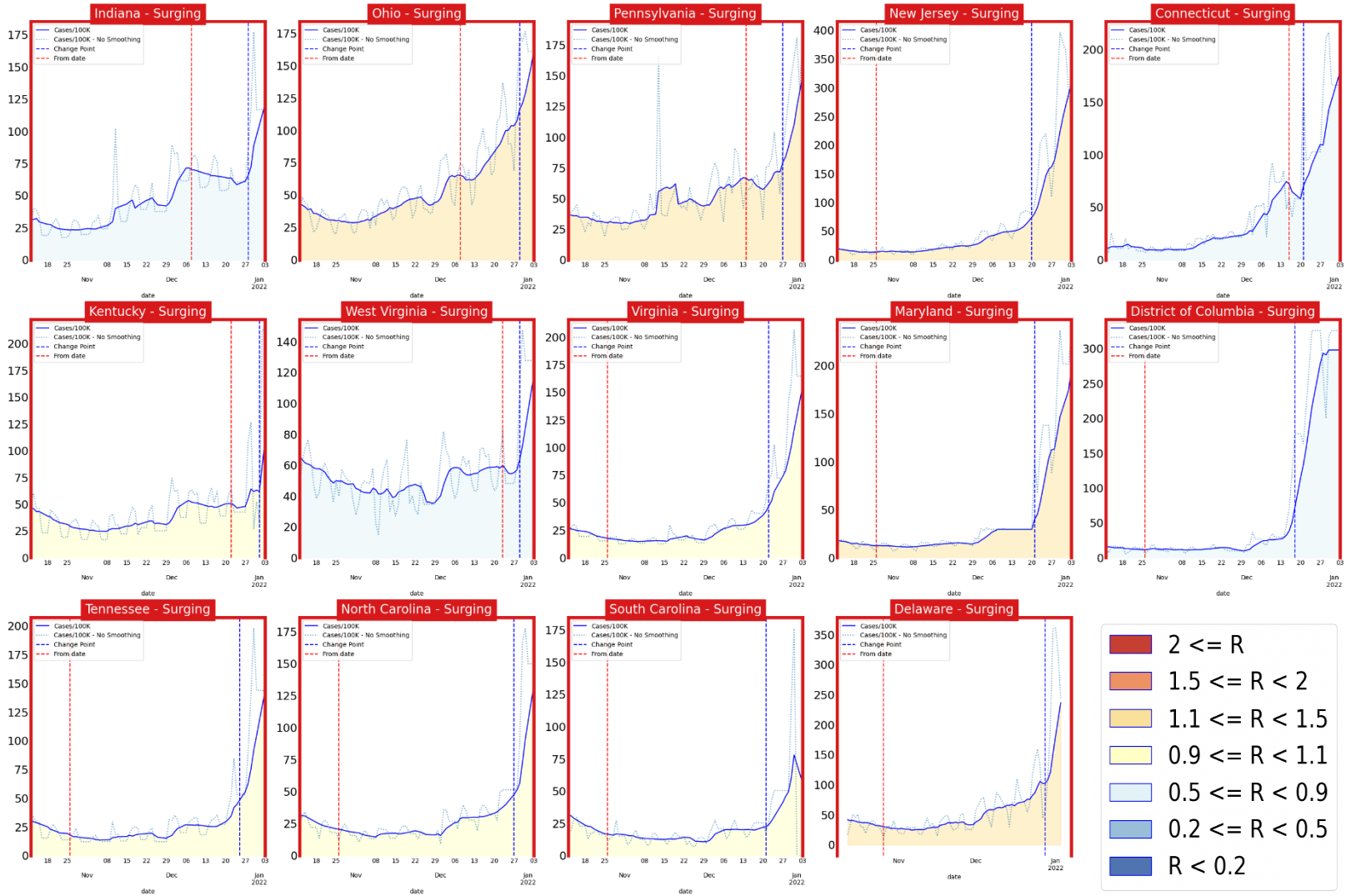
Virginia and Her Neighbors

- All of Virginia and neighbors experiencing rapid growth of case rates
- Nearly all experiencing more than 100/100K daily incident case rates



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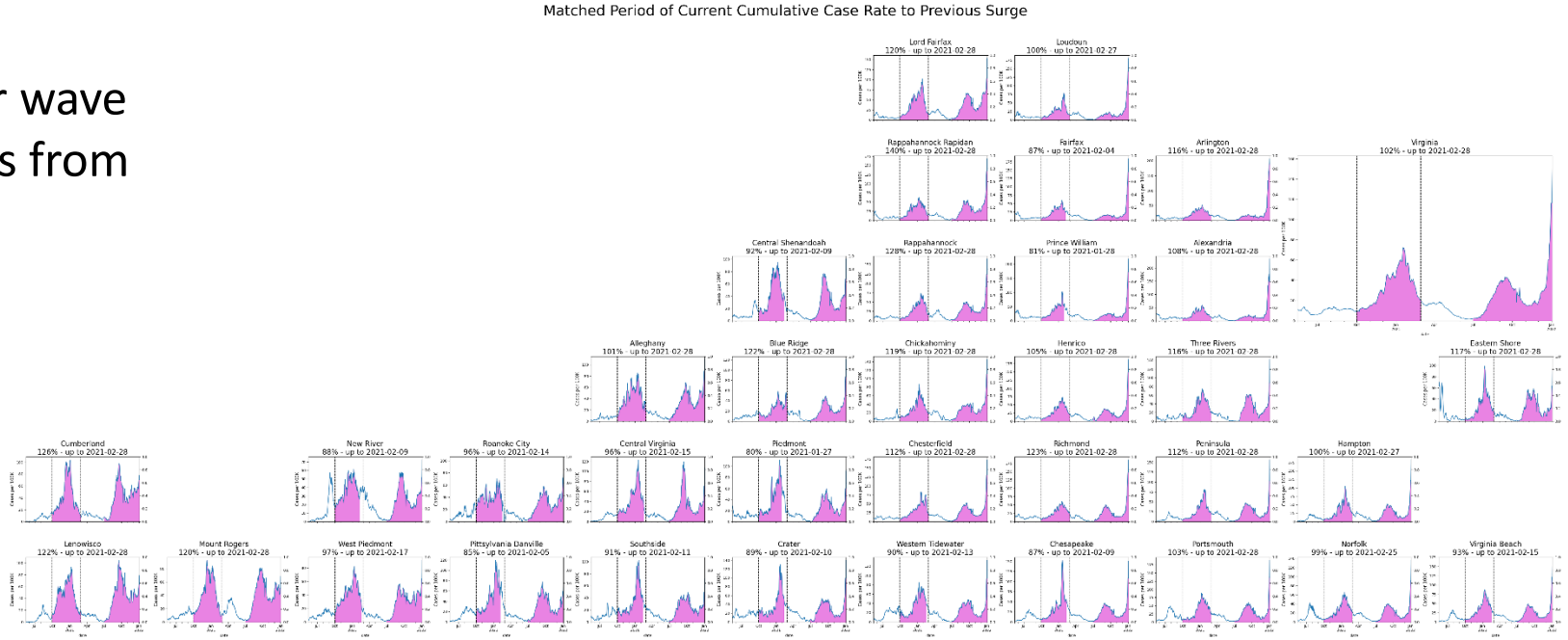
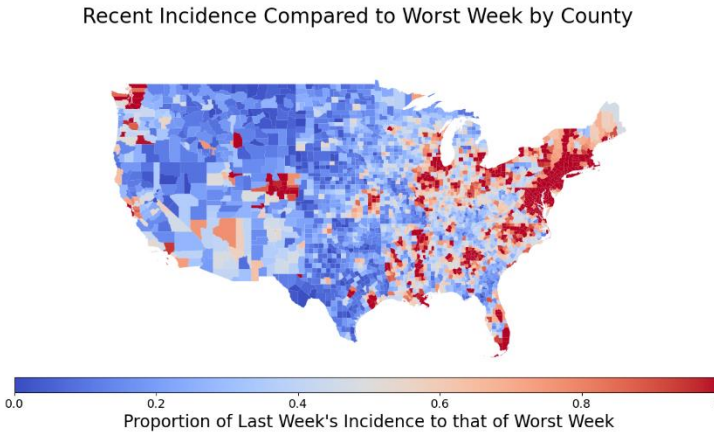
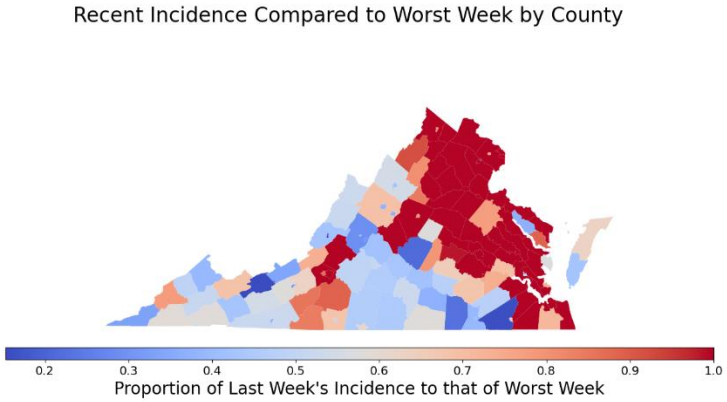
Virginia and Her Neighbors

- Current Delta and Fall-Winter wave have exceeded the total cases from last Fall-Winter wave







- Most counties in Northern and Eastern VA have had the highest case rate of the pandemic in the last week
- Many counties in the mid-Atlantic and Northeast are experiencing their worst week of the pandemic

Zip code level weekly Case Rate (per 100K)

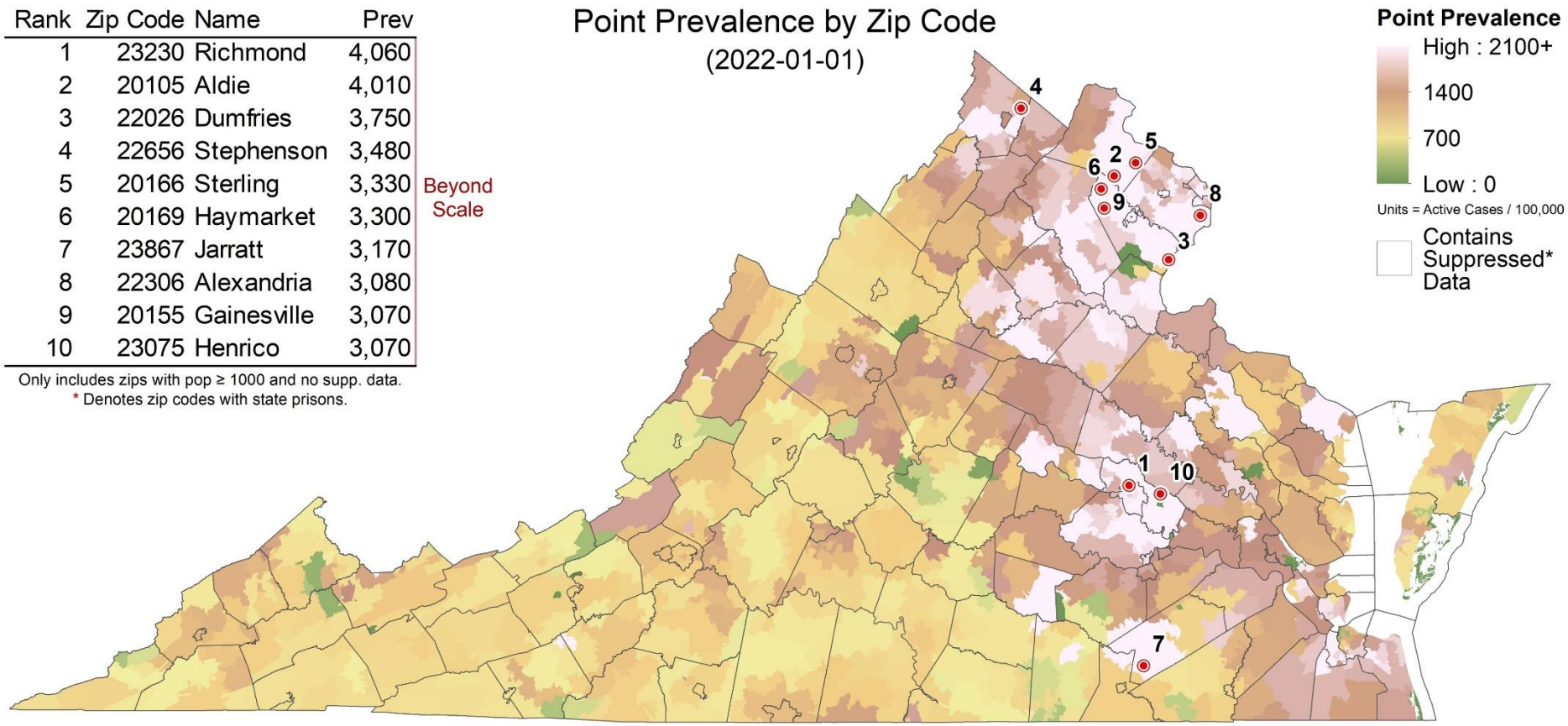
Case Rates in the last week by zip code

- Color scaled adjusted to accommodate the very high prevalence levels this week
- Clusters of high prevalence in Northeast
- Some counts are low and suppressed to protect anonymity, those are shown in white

Rank	Zip Code	Name	Prev
1	23230	Richmond	4,060
2	20105	Aldie	4,010
3	22026	Dumfries	3,750
4	22656	Stephenson	3,480
5	20166	Sterling	3,330
6	20169	Haymarket	3,300
7	23867	Jarratt	3,170
8	22306	Alexandria	3,080
9	20155	Gainesville	3,070
10	23075	Henrico	3,070

Beyond Scale

Only includes zips with pop ≥ 1000 and no supp. data.
* Denotes zip codes with state prisons.



Based on Spatial Empirical Bayes smoothed point prevalence for week ending 2022-01-01.

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Risk of Exposure by Group Size and HCW prevalence

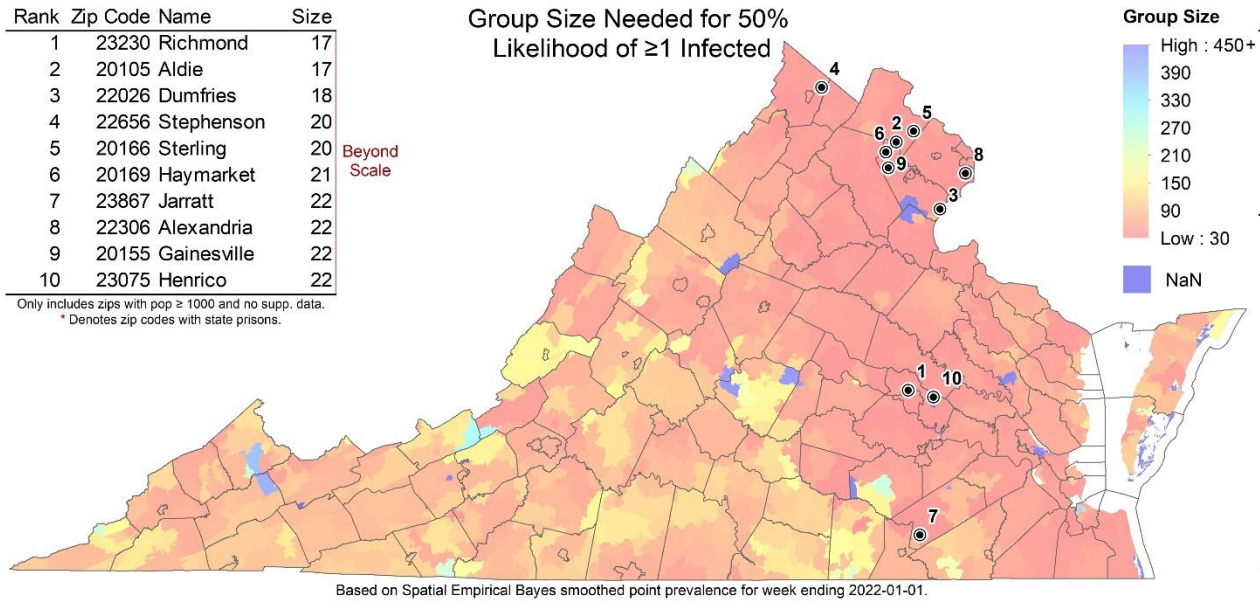
Case Prevalence in the last week by zip code used to calculate risk of encountering someone infected in a gathering of randomly selected people (group size 25)

- **Group Size**: Assumes 2 undetected infections per confirmed case (ascertainment rate from recent seroprevalence survey), and shows minimum size of a group with a 50% chance an individual is infected by zip code (eg in a group of 17 in Richmond, there is a 50% chance someone will be infected)
- **HCW ratio**: Case rate among health care workers (HCW) in the last week using patient facing health care workers as the denominator / general population's case prevalence

Rank	Zip Code	Name	Size
1	23230	Richmond	17
2	20105	Aldie	17
3	22026	Dumfries	18
4	22656	Stephenson	20
5	20166	Sterling	20
6	20169	Haymarket	21
7	23867	Jarratt	22
8	22306	Alexandria	22
9	20155	Gainesville	22
10	23075	Henrico	22

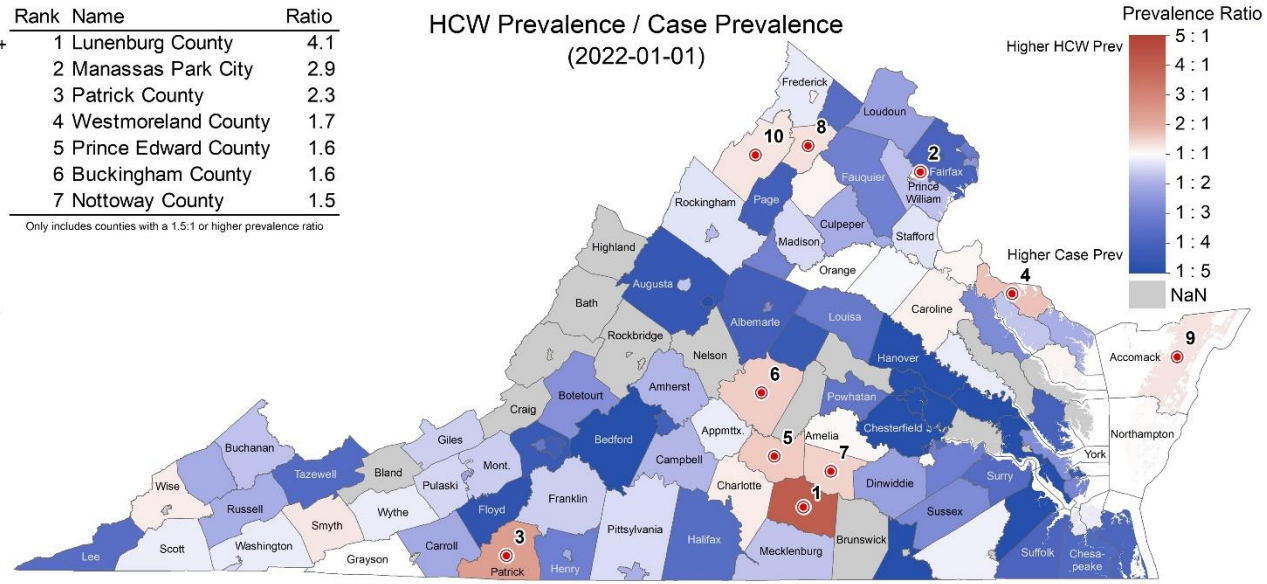
Beyond Scale

Only includes zips with pop ≥ 1000 and no supp. data.
* Denotes zip codes with state prisons.



Rank	Name	Ratio
1	Lunenburg County	4.1
2	Manassas Park City	2.9
3	Patrick County	2.3
4	Westmoreland County	1.7
5	Prince Edward County	1.6
6	Buckingham County	1.6
7	Nottoway County	1.5

Only includes counties with a 1.5:1 or higher prevalence ratio



Current Hot-Spots

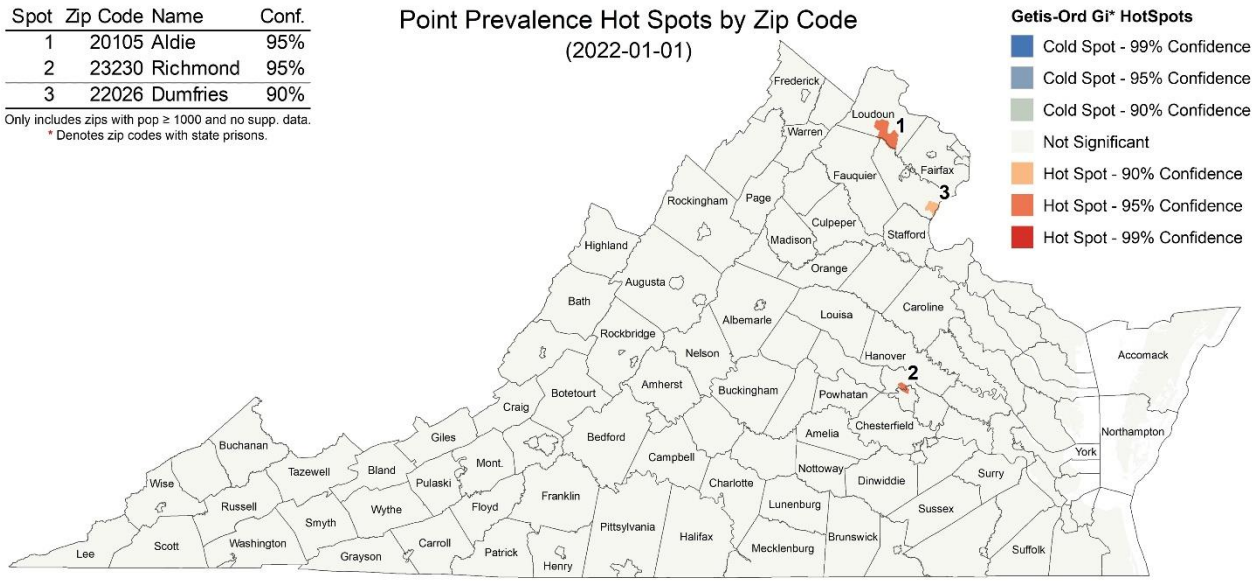
Case rates that are significantly different from neighboring areas or model projections

- **Spatial**: Getis-Ord Gi* based hot spots compare clusters of zip codes with weekly case prevalence higher than nearby zip codes to identify larger areas with statistically significant deviations
- **Temporal**: The weekly case rate (per 100K) projected last week compared to observed by county, which highlights temporal fluctuations that differ from the model's projections

Spatial Hotspots

Spot	Zip Code	Name	Conf.
1	20105	Aldie	95%
2	23230	Richmond	95%
3	22026	Dumfries	90%

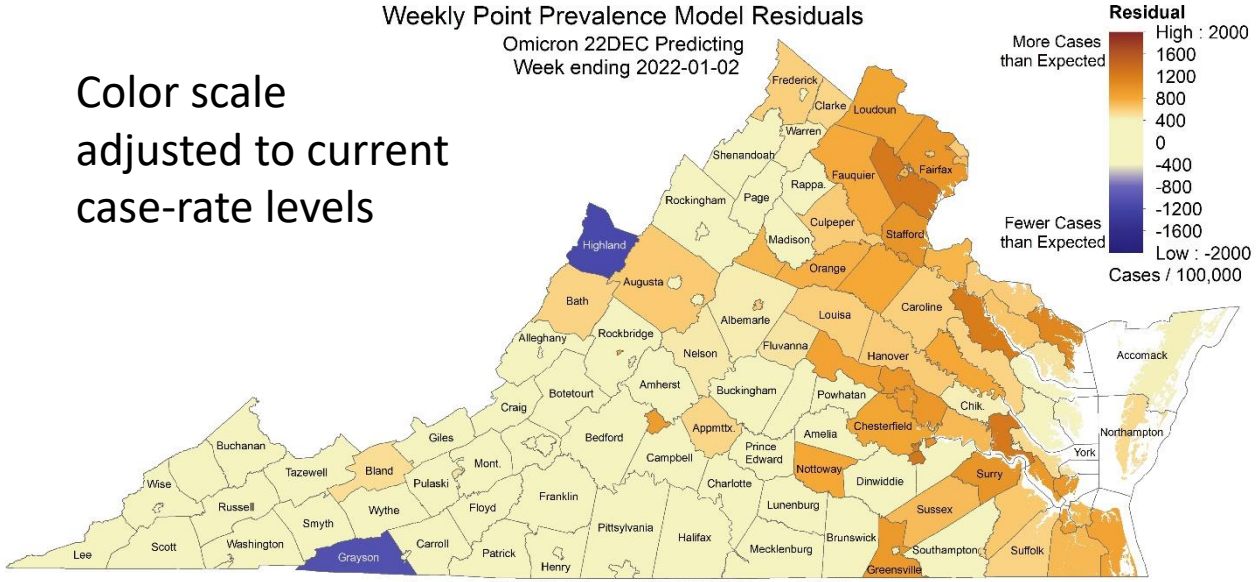
Only includes zips with pop ≥ 1000 and no supp. data.
* Denotes zip codes with state prisons.



Based on Global Empirical Bayes smoothed point prevalence for week ending 2022-01-01.

Clustered Temporal Hotspots

Color scale adjusted to current case-rate levels

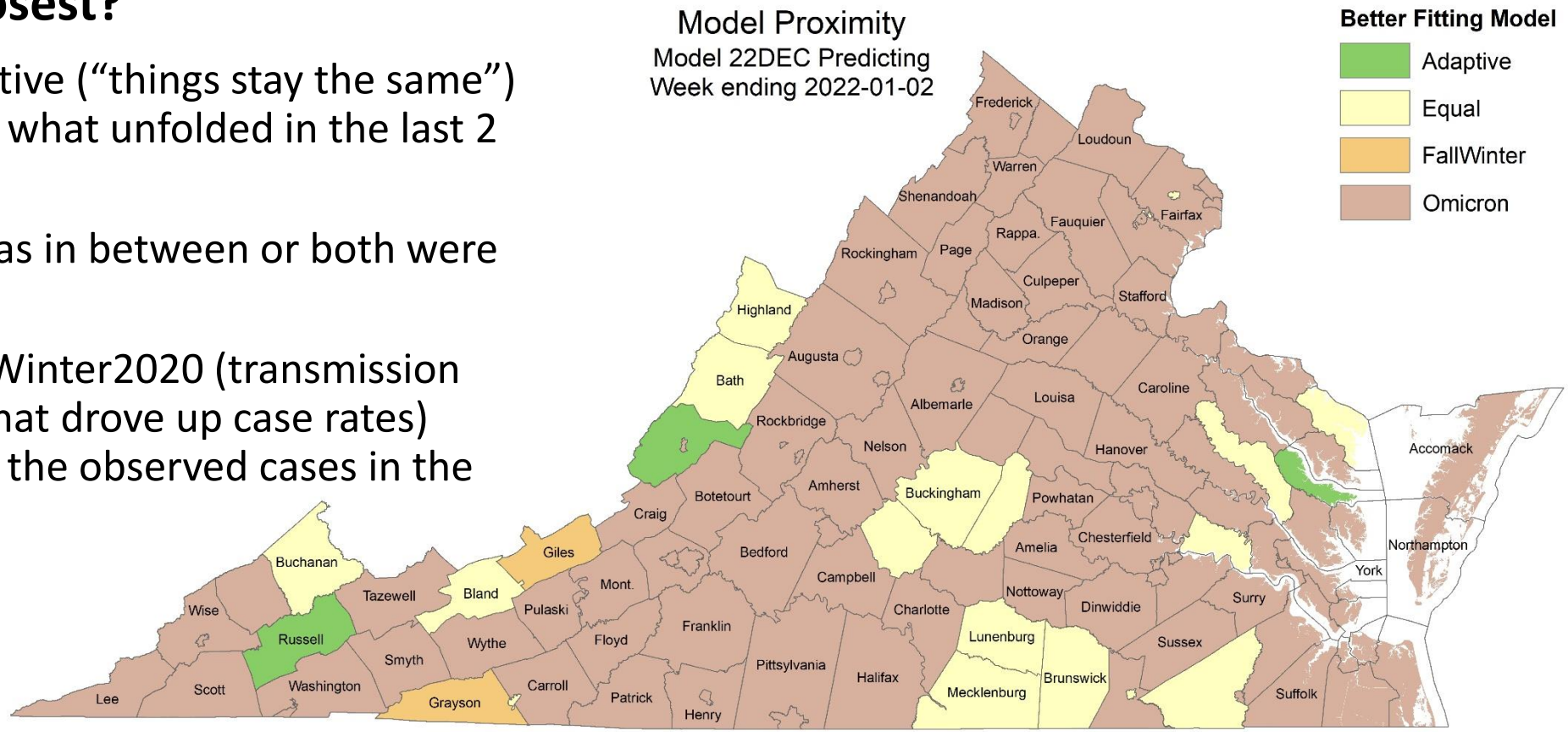


Moran's I = 0.164482, Z-Score = 7.579809, P-Value < 0.0001
Residual Autocorrelation DETECTED

Scenario Trajectory Tracking

Which scenario from last projection did each county track closest?

- Green means the Adaptive (“things stay the same”) scenario was closest to what unfolded in the last 2 weeks
- Yellow means reality was in between or both were very similar
- Orange means the FallWinter2020 (transmission drivers from last year that drove up case rates) scenario was closest to the observed cases in the last 2 weeks

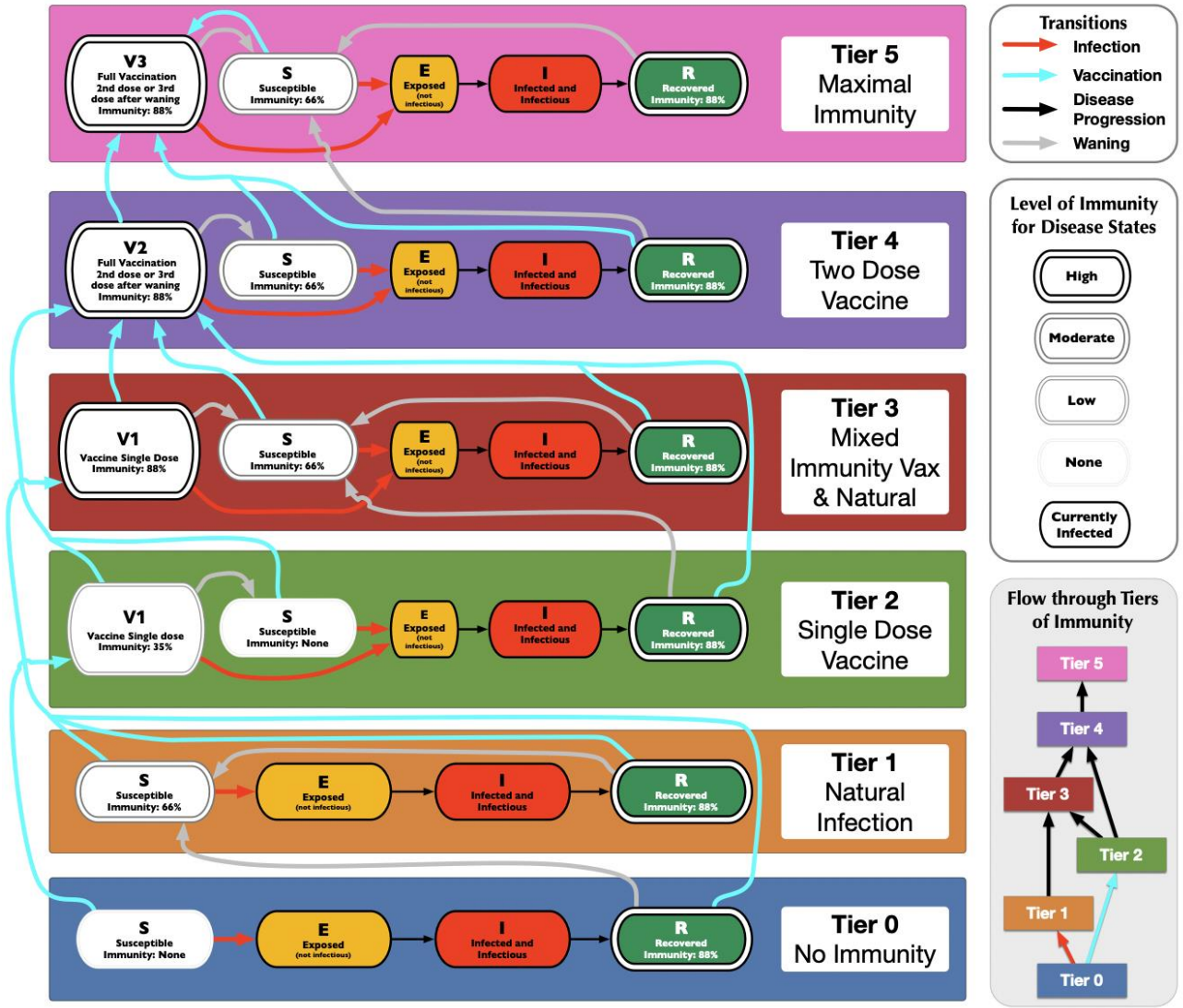


Model Update – Adaptive Fitting

New Model Structure Focused on Tiers of Immunity

Uncertainty surrounds the rate of waning immunity

- New model structure built to better track levels and timing of waning
- Outcomes vary based on age and immune history; for partial immunity, protection against hospitalization and death is stronger than No Immunity but weaker than Maximal Immunity
- Use same Adaptive fitting approach with vaccine schedules and simulated infections driving movement across the tiers
- Different Scenarios can also be applied



Adaptive Fitting Approach

Each county fit precisely, with recent trends used for future projection

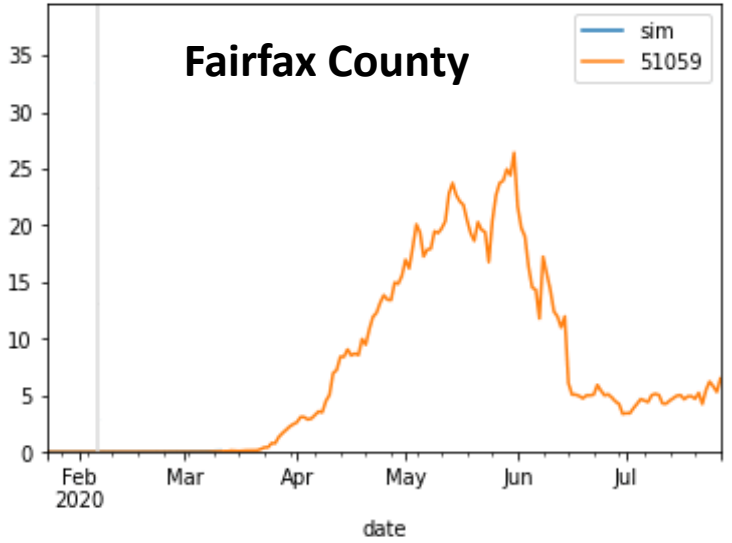
- Allows history to be precisely captured, and used to guide bounds on projections

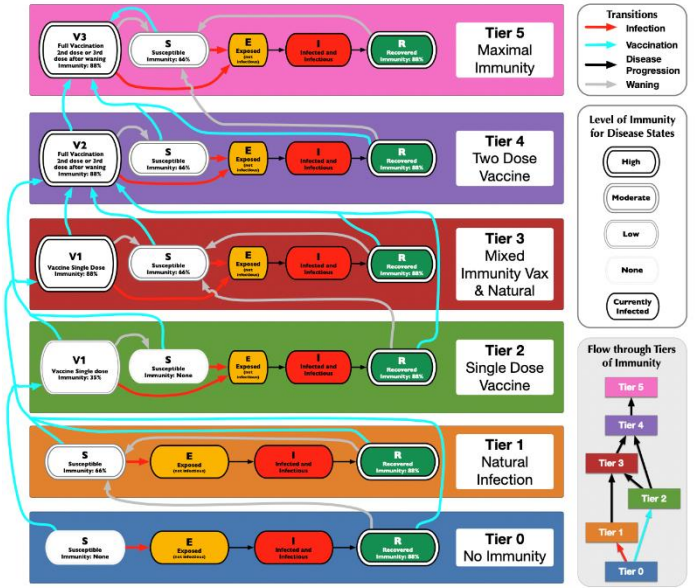
Model: An alternative use of the same meta-population model, PatchSim with multiple tiers of immunity

- Allows for future "what-if" Scenarios to be layered on top of calibrated model
- Allows for waning of immunity and for partial immunity against different outcomes (eg lower protection for infection than death)

External Seeding: Steady low-level importation

- Widespread pandemic eliminates sensitivity to initial conditions, we use steady 1 case per 10M population per day external seeding





Using Ensemble Model to Guide Projections

Ensemble methodology that combines the Adaptive [illegible] machine learning and statistical models such as:

- Autoregressive (AR, ARIMA)
- Neural networks (LSTM)
- Kalman filtering (EnKF)

Weekly forecasts done at co[illegible]el.

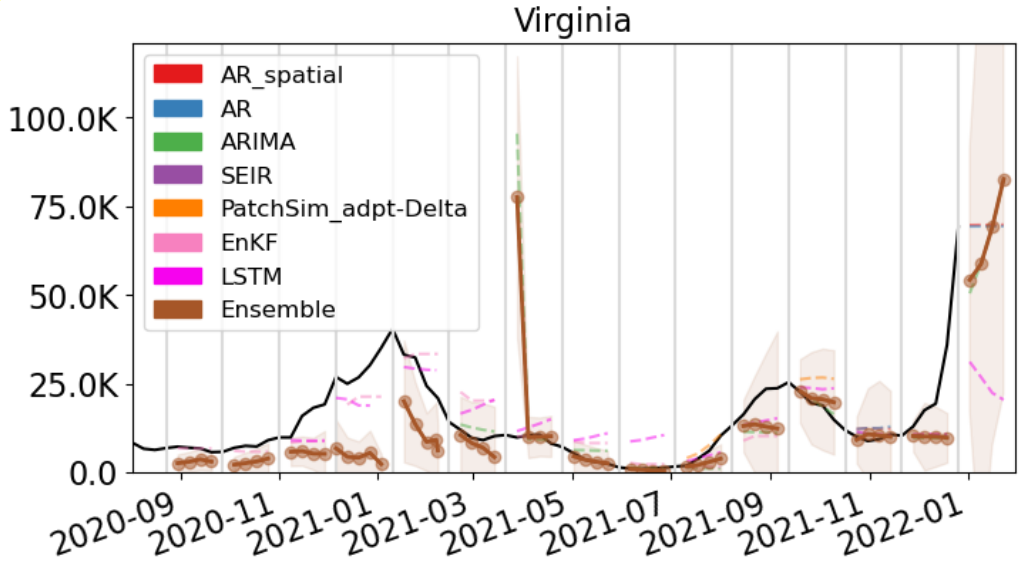
Models chosen because [illegible] track record in disease forecasting and to in[illegible]iversity and robustness.

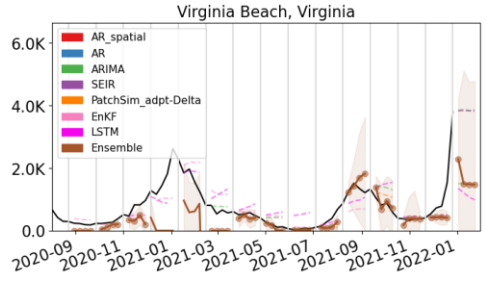
Ensemble fore[illegible]ovides additional 'surveillance' for making sce[illegible]ased projections.

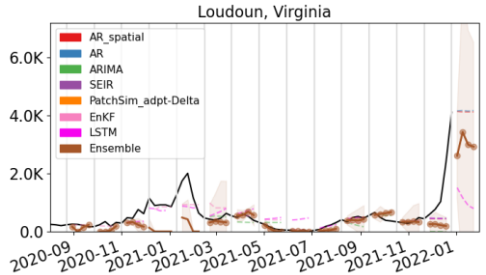
Also su[illegible]itted to CDC Forecast Hub.

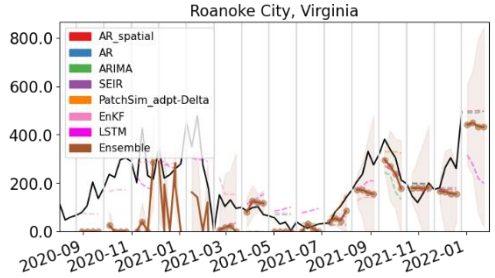
Ensemble not well calibrated to Omicron therefore not used for this week's projections

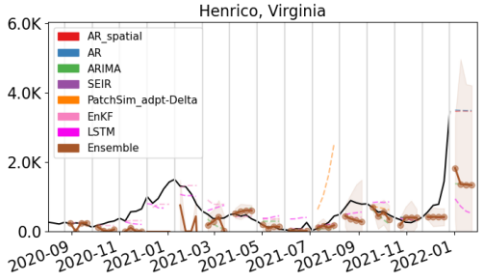
Plots updated for additional situational awareness











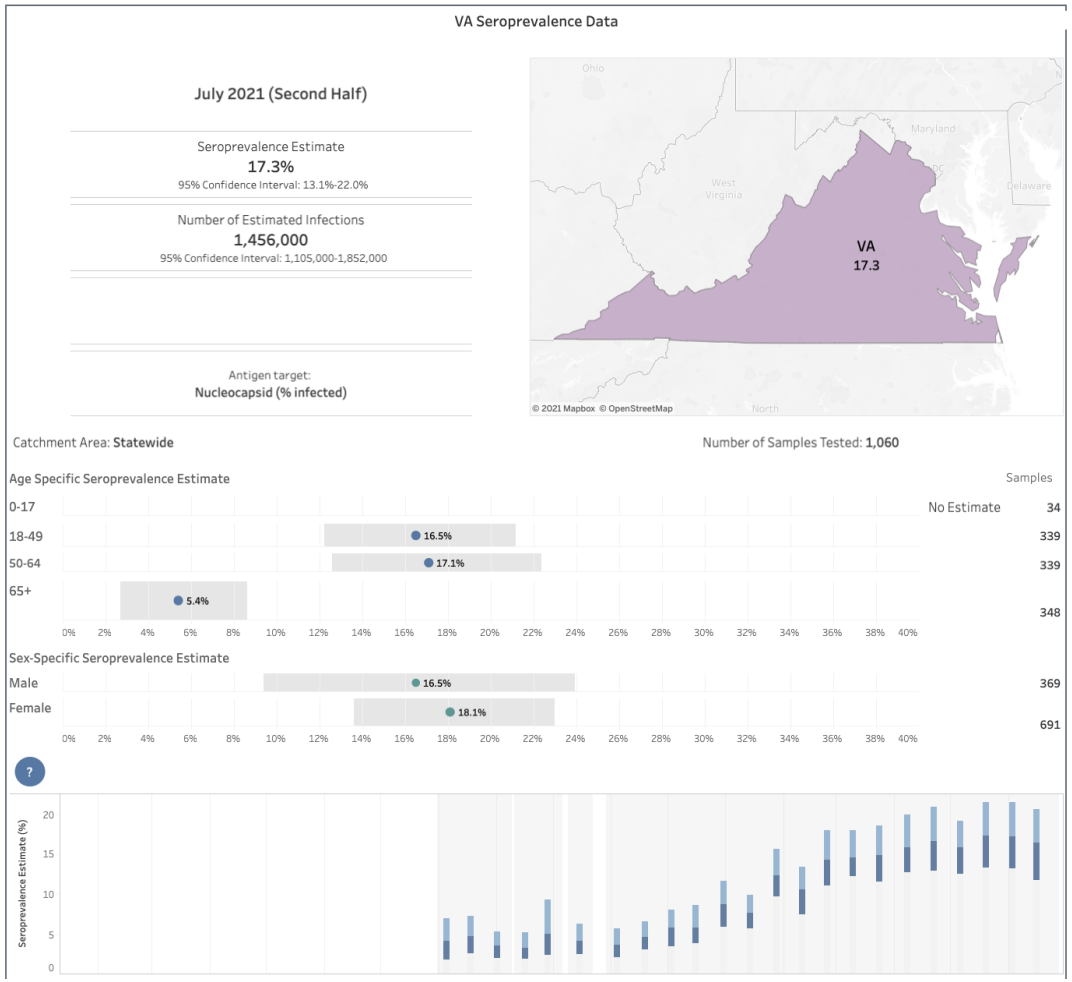
Seroprevalence updates to model design

Several seroprevalence studies provide better picture of how many actual infections have occurred

- CDC Nationwide Commercial Laboratory Seroprevalence Survey

These findings are equivalent to an ascertainment ratio of ~2x in the future, with bounds of (1.3x to 3x)

- Thus for 2x there are 2 total infections in the population for every confirmed case recently
- **Case ascertainment is half of that for those with prior immunity**
- Uncertainty design has been shifted to these bounds (previously higher ascertainments as was consistent earlier in the pandemic were being used)



https://covid.cdc.gov/covid-data-tracker/#national-lab

Calibration Approach

- **Data:**
  - County level case counts by date of onset (from VDH)
  - Confirmed cases for model fitting
- **Calibration:** fit model to observed data and ensemble's forecast
  - Tune transmissibility across ranges of:
    - Duration of incubation (5-9 days), infectiousness (3-7 days)
    - Undocumented case rate (1x to 7x) guided by seroprevalence studies
    - Detection delay: exposure to confirmation (4-12 days)
  - Approach captures uncertainty, but allows model to precisely track the full trajectory of the outbreak
- **Project:** future cases and outcomes generated using the collection of fit models run into the future
  - **Mean trend from last 7 days of observed cases and first week of ensemble's forecast used**
  - Outliers removed based on variances in the previous 3 weeks
  - 2 week interpolation to smooth transitions in rapidly changing trajectories
- **Outcomes**: Data driven by shift and ratio that has least error in last month of observations
  - Hospitalizations: 3 days from confirmation, 6.8% of cases hospitalized
  - Deaths: 11 days from confirmation, 1.45% of cases die

VIRGINIA'S HEALTH IS IN OUR HANDS. Do your part, stop the spread.

COVID-19 in Virginia:

VDH VIRGINIA DEPARTMENT OF HEALTH

Dashboard Updated: 1/5/2022
Data entered by 5:00 PM the prior day.

Cases, Hospitalizations and Deaths

Total Cases*	Total Hospitalizations**	Total Deaths
1,186,887	43,449	15,631
(New Cases: 10,728)^		

Confirmed†	Probable†	Confirmed†	Probable†	Confirmed†	Probable†
852,876	334,011	40,930	2,519	13,053	2,578

* Includes people with either a positive molecular/PCR test (Confirmed), positive antigen test (Probable) or symptomatic with known exposure to COVID-19 (Probable).
** Hospitalization of a case is captured at the time VDH performs case investigation. This underrepresents the total number of hospitalizations in Virginia.
^New cases represent the number of confirmed and probable cases reported to VDH in the past 24 hours.
† VDH adopted the updated CDC COVID-19 2021 Surveillance Case Definition on September 1, 2021 which is found here: -- https://ndc.services.cdc.gov/case-definitions/coronavirus-disease-2019-2021/
Source: Cases - Virginia Electronic Disease Surveillance System (VEDSS), data entered by 5:00 PM the prior day.

Outbreaks

Total Outbreaks*	Outbreak Associated Cases
6,229	98,269

* At least two (2) lab confirmed cases are required to classify an outbreak.

Testing (PCR Only)

Testing Encounters PCR Only*	Current 7-Day Positivity Rate PCR Only**
11,352,582	32.0%

* PCR" refers to "Reverse transcriptase polymerase chain reaction laboratory testing."
** Lab reports may not have been received yet. Percent positivity is not calculated for days with incomplete data.

Multisystem Inflammatory Syndrome in Children

Total Cases*	Total Deaths
125	1

*Cases defined by CDC HAN case definition: https://emergency.cdc.gov/han/2020/han00432.asp

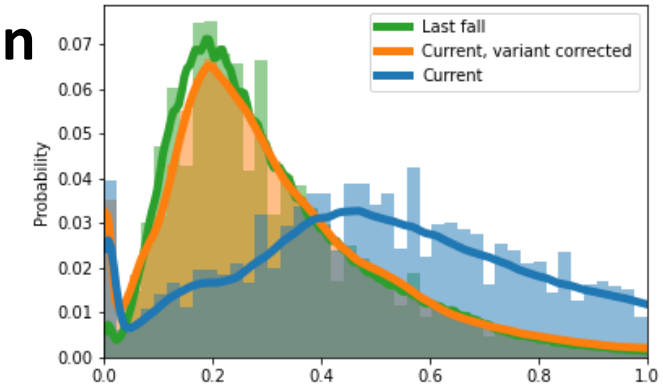
Accessed 9:30am January 5, 2022
https://www.vdh.virginia.gov/coronavirus/

Scenarios – Transmission Conditions

- Variety of factors continue to drive transmission rates
  - Seasonal impact of weather patterns, travel and gatherings, fatigue and premature relaxation of infection control practices
- **Waning Immunity**: Mean of 6 months to a re year protection (rate of 0.0027) similar to Pfizer study
- **Projection Scenarios**:
  - **Adaptive:** Control remains as is currently experienced into the future with assumption that Delta remains as the majority strain
  - **Adaptive-Omicron:** Controls remain the same while the Omicron rapidly dominates prevalence. Has same transmissibility as Delta with 80% immune evasion
  - **Adaptive-FallWinter:** Starting this week the drivers of transmission from last Fall-Winter's wave are coarsely replayed; rates dropped dramatically after the peak last Jan 17th (by roughly 60%). This scenario now replays this stark drop as if history repeats itself.
  - **Adaptive-Surge Control:** Starting in one week behaviors and mitigation efforts ramp up over a 2-week period culminating in a 25% reduction in transmission

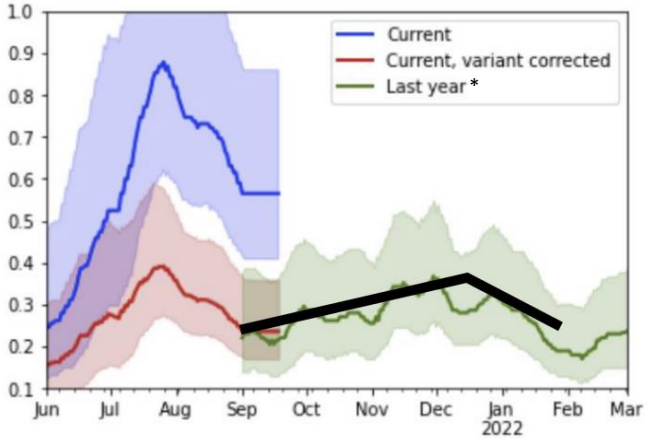
Scenarios – FallWinter Description

September 2020 – February 2021 saw a strong wave of transmission

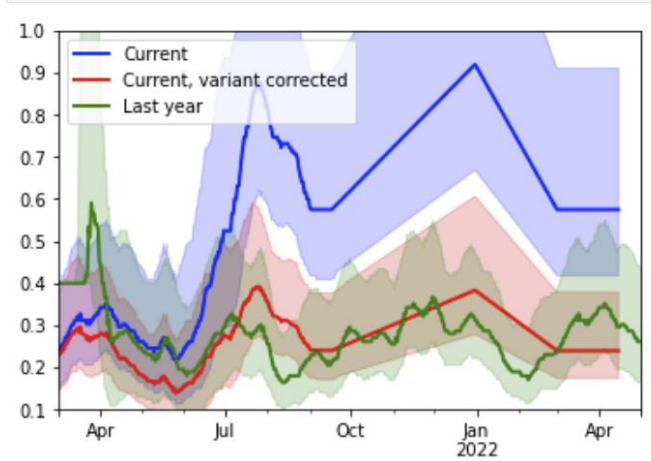


- We analyze previous Fall-Winter's wave vs. current Delta driven wave and observe surprising similarities
  - The distribution of fitted model transmissibility is nearly identical between these periods when corrected for Delta's increased transmissibility
- **FallWinter** tries to capture the "transmission drivers" from the past and use them as if they were to occur again this season but with Delta variant (compared to ancestral)
  - Use the above analysis of fitted model transmissibilities from Sept 2020 – Feb 2021 to guide the future transmissibility from Sept 2021 through Feb 2022, but add the enhanced transmissibility of Delta back in

Fitting:
Black line represents the coarsely fitted base transmissibility



* "Last year" is transplanted into 2021-22



Delta enhanced:
Blue trajectory represents current fitted and then projected transmissibility in FallWinter2020

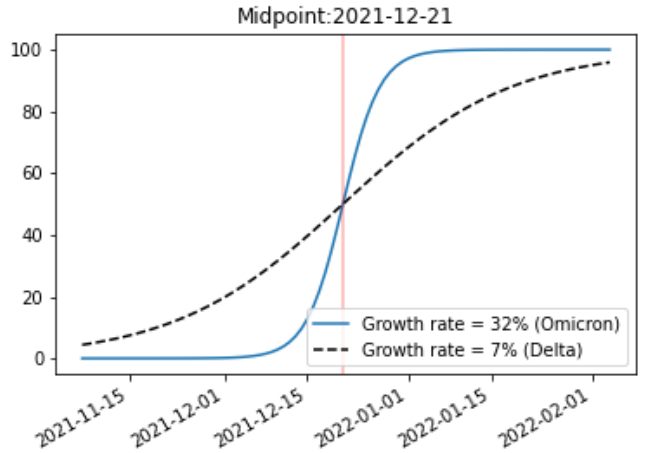
Scenarios – Omicron Description

Omicron shown ability to evade immunity and may be more transmissible

- **Transmissibility**: New evidence suggests that Omicron has **similar transmissibility** to Delta
- **Immune Evasion**: Strong evidence demonstrates that Omicron can cause infection in those with some immunity (natural and vaccine induced). Consensus estimate of **80% immune evasion** allows Omicron to infect 80% of individuals that would have otherwise been protected against Delta
- **Prevalence**: Proportion of cases caused by Omicron variant estimated from growth rates observed in other countries with similar levels of immunity (growth of 32%, doubling in ~3 days)
- **Severity:** Several reports suggest Omicron may not cause as severe disease as Delta, we use a 50% reduction in severity for hospitalizations and deaths
- Studies: South Africa, UK, Canada

Previous conservative estimates proved to be so, as last projections underpredicted growth.
These consensus estimates may over predict as human behavior and testing may be outpaced by rapid growth

Estimated Prevalence curve for US



Predominance occurs before Jan 1, 2022

Projection Scenarios – Combined Conditions

Name	Txm Controls	Vax	Description
Adaptive	C	SQ	Likely trajectory based on conditions remaining similar to the current experience
Adaptive-Omicron	C	SQ	Assumes rapid dominance of immune evading variant. Conservatively uses no transmission advantage to Delta but 80% of previously immune individuals are susceptible to infection from Omicron
Adaptive-Omicron-SurgeControl	25%	SQ	Transmission rates in the next month reduced through increased control from non-pharmaceutical interventions, with status quo vax and Delta
Adaptive-Omicron-FallWinter	FallWinter	SQ	Transmission rates coarsely follow the rates from last September through this February but are boosted by Delta's enhanced transmissibility

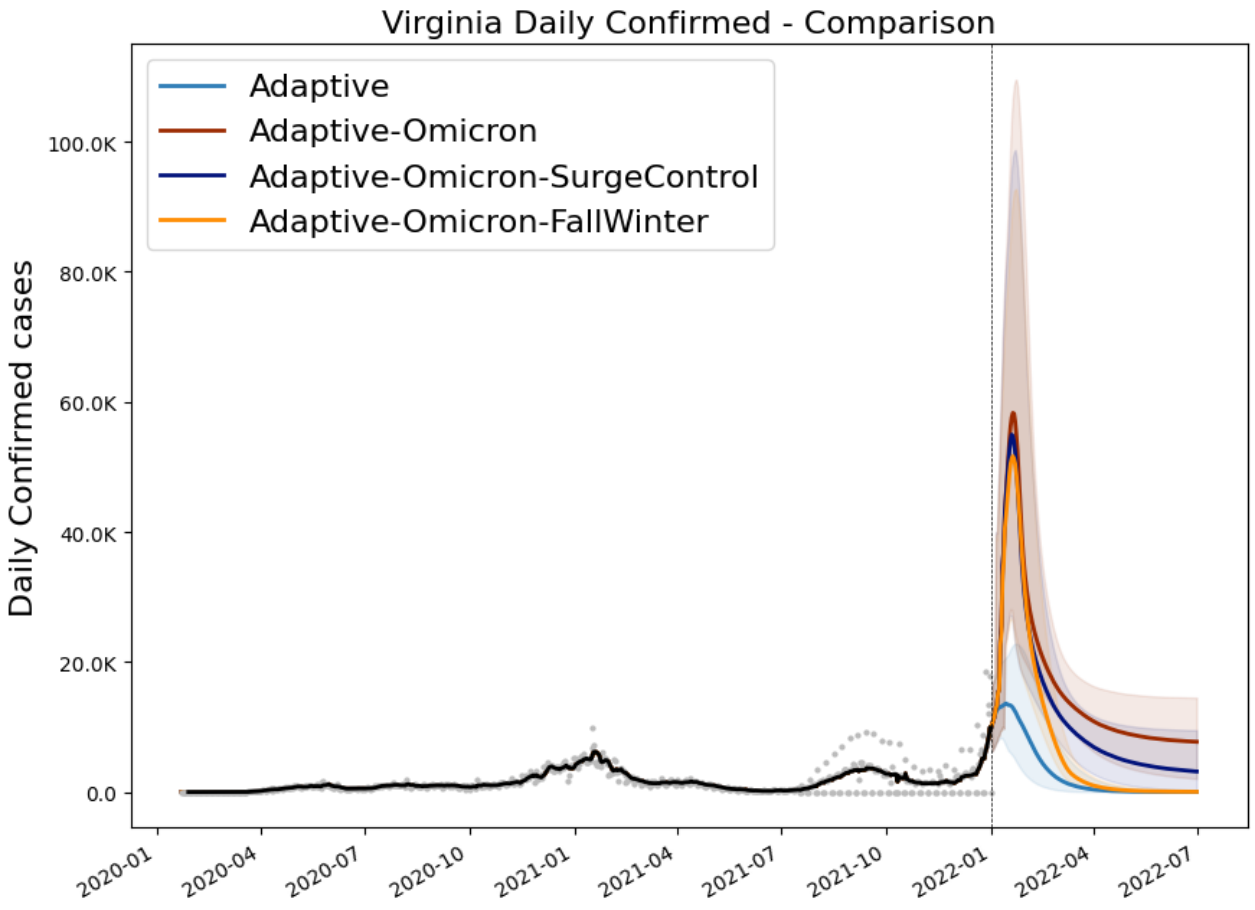
Transmission Controls:
C = Current levels persist into the future
25% = Transmission rates are reduced by 25% with a gradual introduction, concluding in 4 weeks
FallWinter2020 = Transmission rates from Sept 2020 – Feb 2021 are coarsely replayed but boosted by Delta's increased transmissibility

Vaccinations:
SQ = Status quo acceptance leads to low rates of vaccination through the summer
VO = Vaccination acceptance optimistically expands with increased rates through the summer

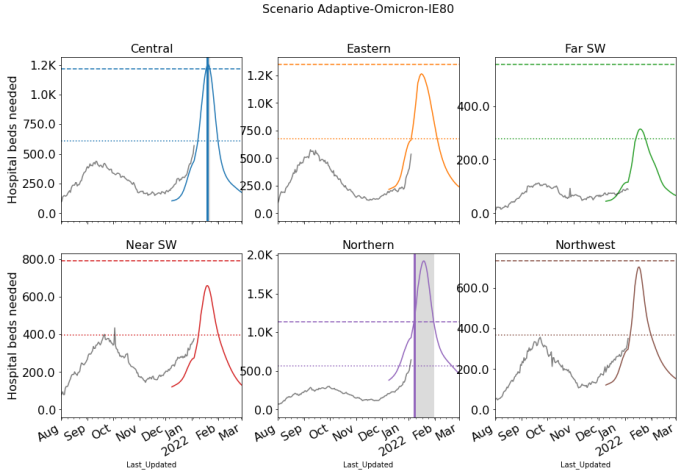
Model Results

Outcome Projections

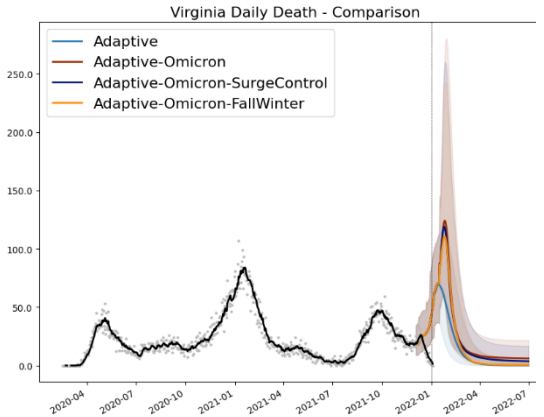
Confirmed cases



Estimated Hospital Occupancy

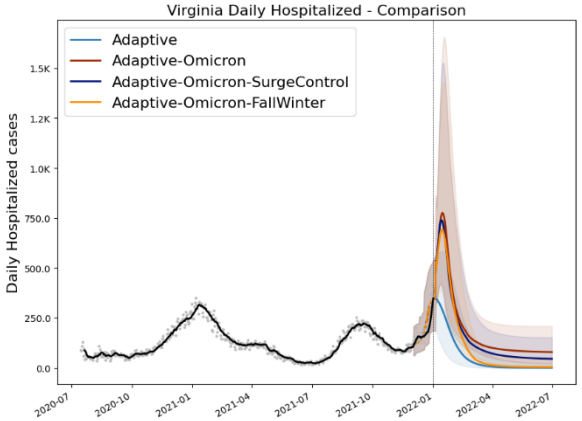


Daily Deaths



Death ground truth from VDH "Event Date" data, most recent dates are not complete

Daily Hospitalized



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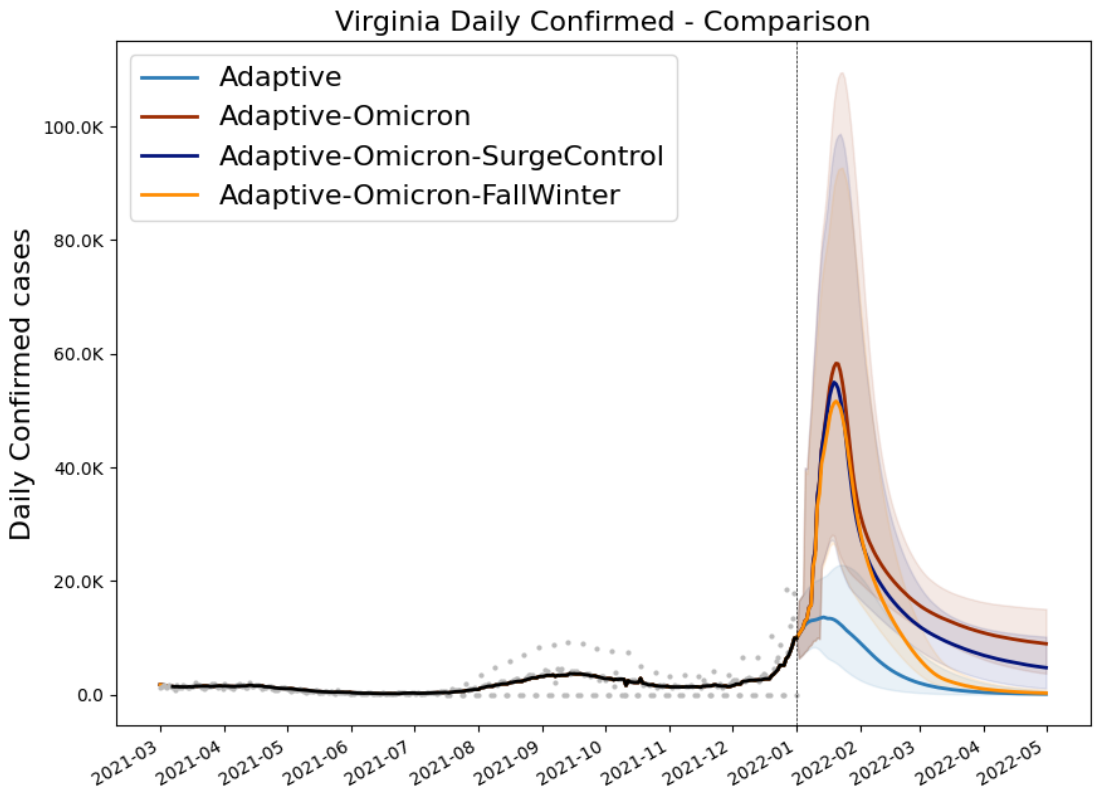
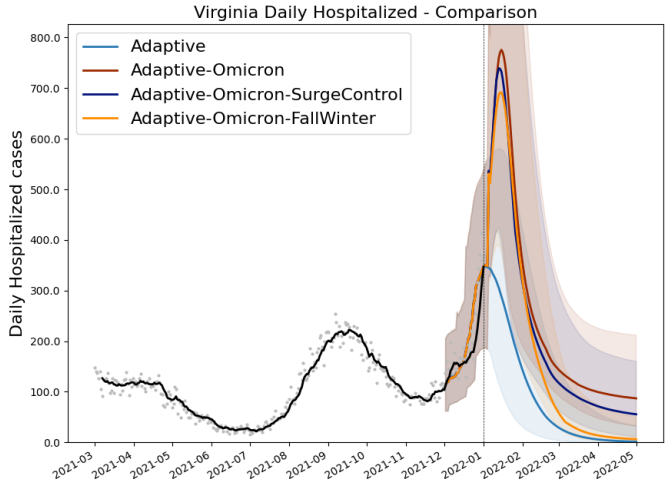
Outcome Projections – Closer Look

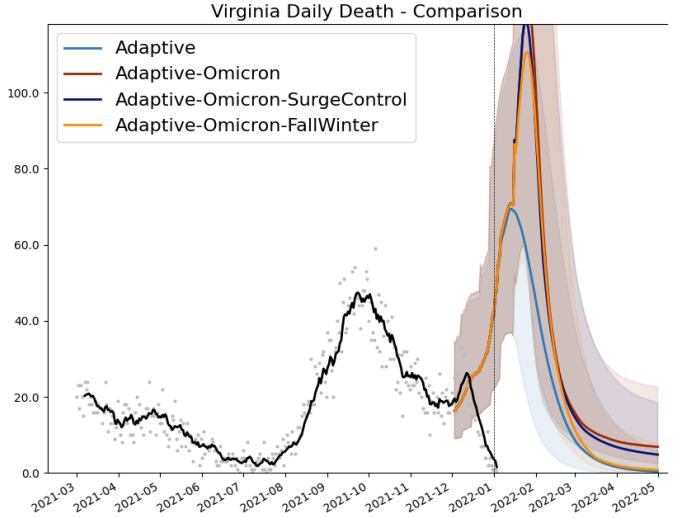
Confirmed cases



Daily Hospitalized



Daily Deaths



Death ground truth from VDH "Event Date" data, most recent dates are not complete

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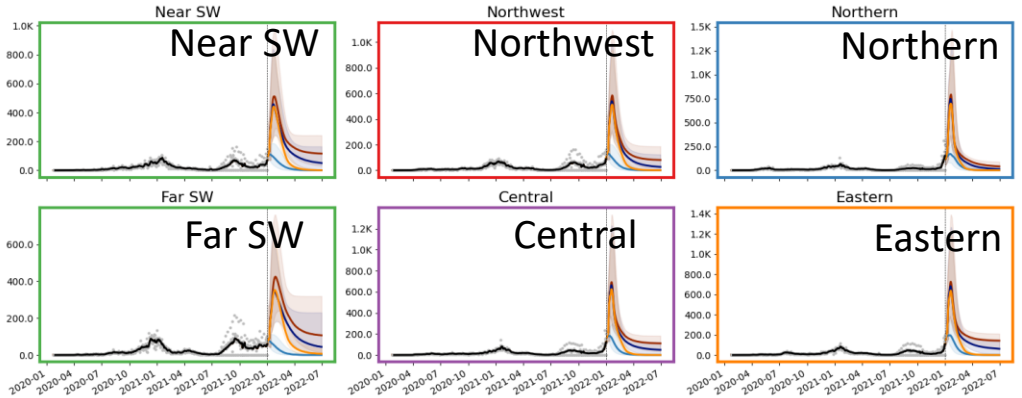
Detailed Projections: All Scenarios

Projections by Region

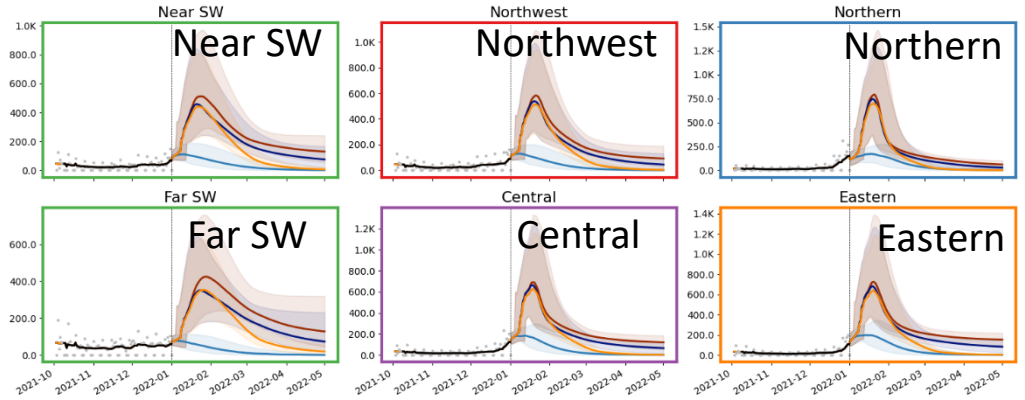


Projections by District

Daily confirmed cases) by rate (per 100K) District (grey with 7-day average in black) with simulation colored by scenario

Detailed Projections: All Scenarios - Closer Look

Projections by Region



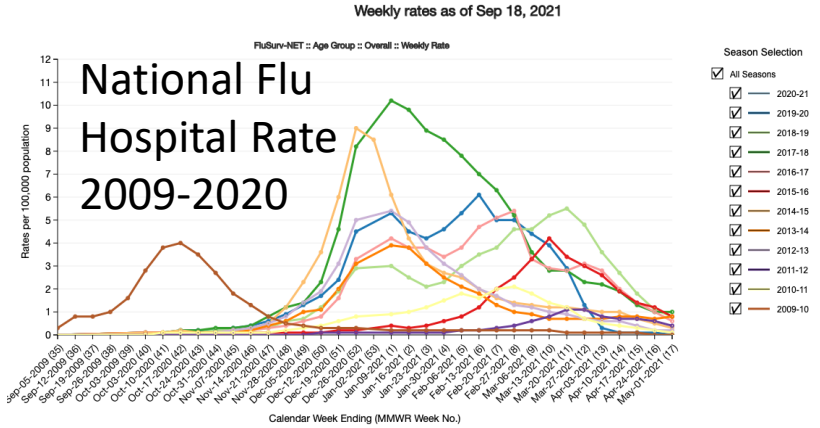
Projections by District

Daily confirmed cases by rate (per 100K) District (grey with 7-day average in black) with simulation colored by scenario

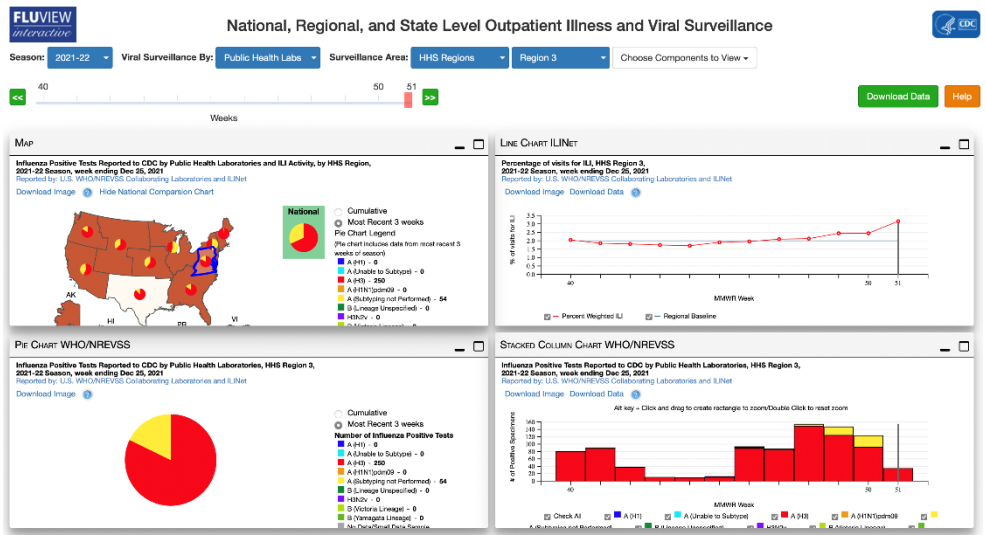
Impact of Influenza based on Previous Intense Flu Seasons

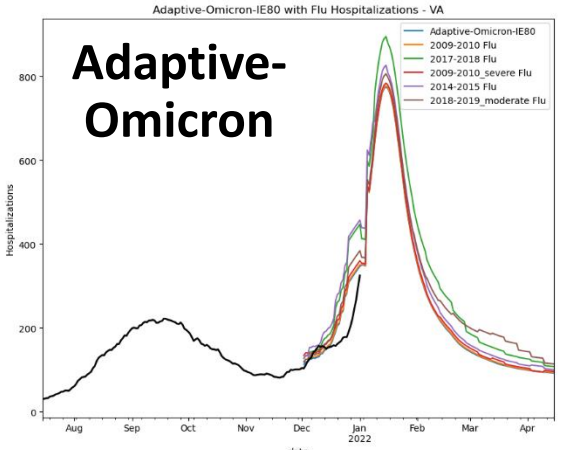
Augment COVID-19 daily hospitalizations with that of past Influenza seasons

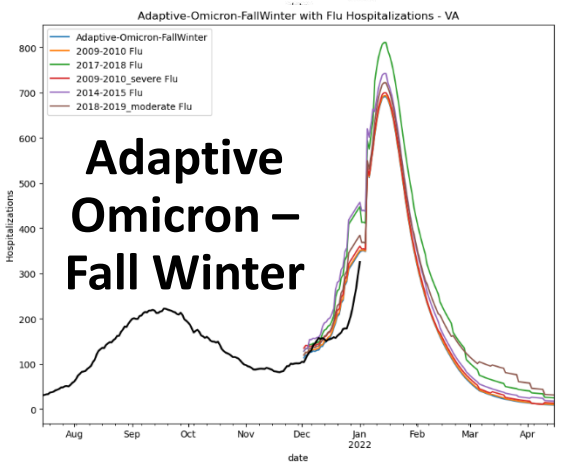
- Include hybrid seasons that use timing of one season but are scaled by severity of another
- Due to limited historical data on Virginia flu hospitalizations currently using national rates applied to VA population



https://gis.cdc.gov/GRASP/Fluview/FluHospRates.html







2009-10 – Pandemic 2009 H1N1 season

2017-18 – Timing and severity of 2017-18 season

2009-10_severe – Timing of 2009 pandemic (early) with the severity of the 2017-18 season

2014-15 – Timing and severity of 2014-15 season

2018-19_moderate – Timing of 2018-19 (late) season with severity of 2014-15

Influenza A activity up in our region
Labs show high levels of H3 this season
(Influenza A H3N2 is more severe)

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Key Takeaways

Projecting future cases precisely is impossible and unnecessary.
Even without perfect projections, we can confidently draw conclusions:

- **Case rates have accelerated to unprecedented levels throughout the commonwealth**
- VA 7-day mean daily case rate up to 155/100K from 79/100K; US is up to 144/100K (from 80/100K)
- Projections show a continued sharp rise in case-rates for several weeks:
  - Omicron is able to infect and transmit more between those with immunity from previous infections and vaccinations; hospitalizations will also rise despite reduced severity as case-rates out pace this reduction
  - Case ascertainment will drop as fewer infections cause severe disease, testing capacities are met, and at-home testing rises
- Recent model updates:
  - Overhauled model structure further refined to better capture different tiers of immunity and the immune evasion of the Omicron variant

The situation continues to change. Models continue to be updated regularly.

Additional Analyses

Overview of relevant on-going studies

Other projects coordinated with CDC and VDH:

- **Scenario Modeling Hub:** Consortium of academic teams coordinated via MIDAS / CDC to that provides regular national projections based on timely scenarios
- **Genomic Surveillance:** Analyses of genomic sequencing data, VA surveillance data, and collaboration with VA DCLS to identify sample sizes needed to detect and track outbreaks driven by introduction of new variants etc.
- **Mobility Data driven Mobile Vaccine Clinic Site Selection:** Collaboration with VDH state and local, Stanford, and SafeGraph to leverage anonymized cell data to help identify

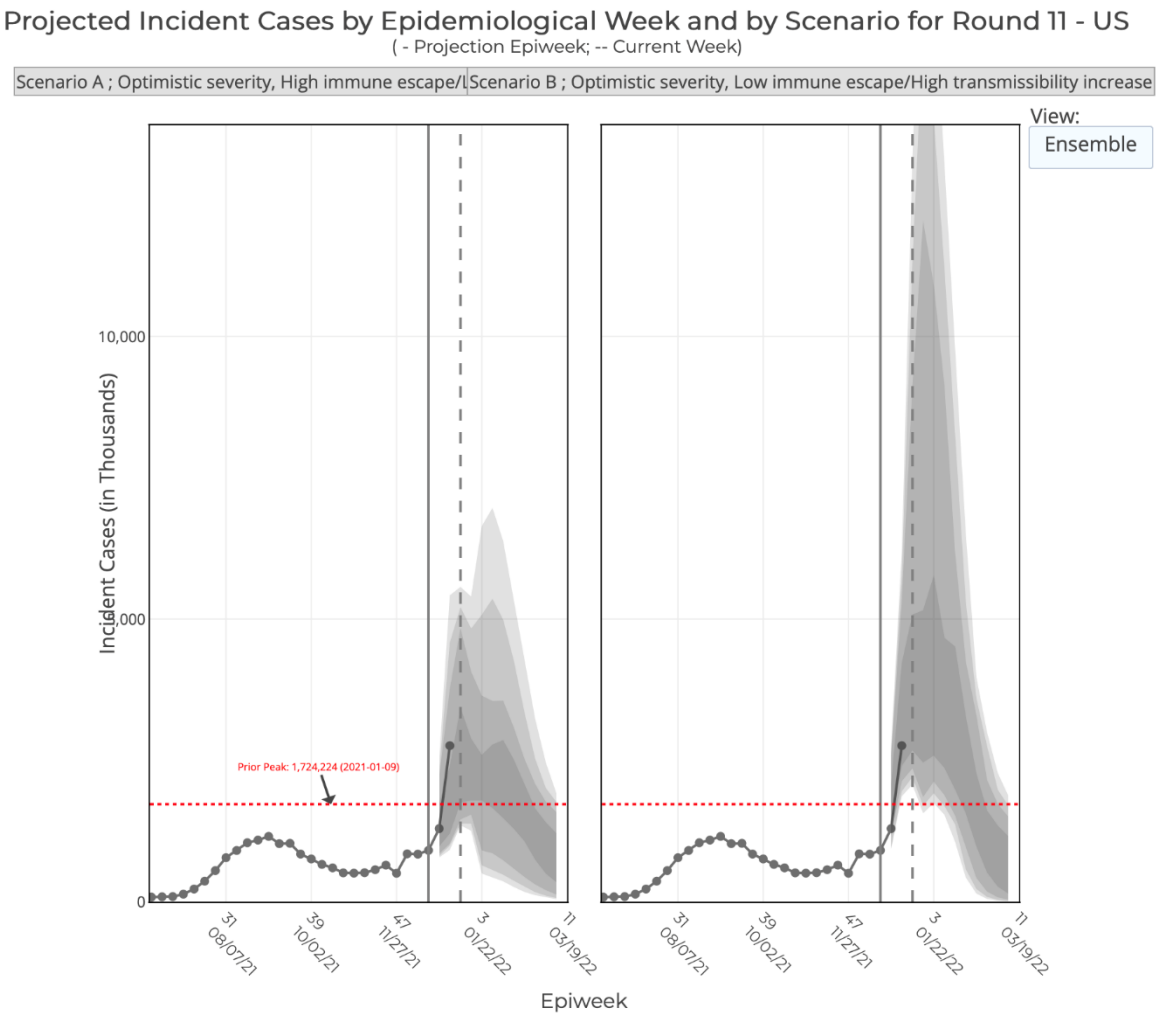
COVID-19 Scenario Modeling Hub

Collaboration of multiple academic teams to provide national and state-by-state level projections for 4 aligned scenarios that vary vaccine rates (high – low) and impact of the Delta variant (high and low)

- Round 11 recently released to assist in federal response to Omicron wave
- Only national consortium tracking Omicron wave well
- Rounds 4-11 now available

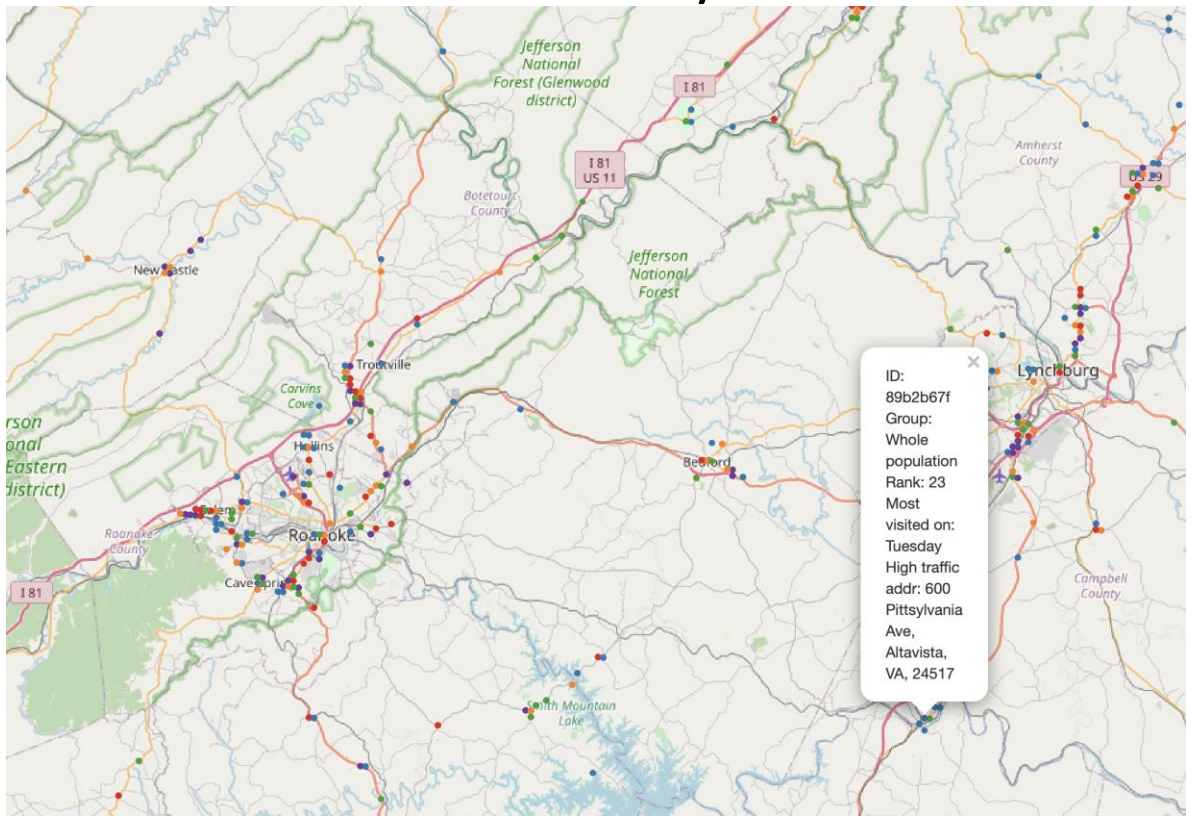
Round 4 Results were published May 5th, 2021 in MMWR

https://covid19scenariomodelinghub.org/viz.html



Data Recommended Mobile Vax Clinic Sites

Detailed and Timely Locations



Data Delivered and Disseminated to Locals

Provides a list of areas most visited by a given demographic group based on SafeGraph mobility data that links visits to specific sites and the home Census Block Group of the anonymized visitors

Demographic Groups: Black, Lantinx, Young Adults (20-40), Unvaccinated, and Whole Population

Data Included: Rank, Weight, most visited Day of Week, Highly Visited Address, and Lat-Long of area

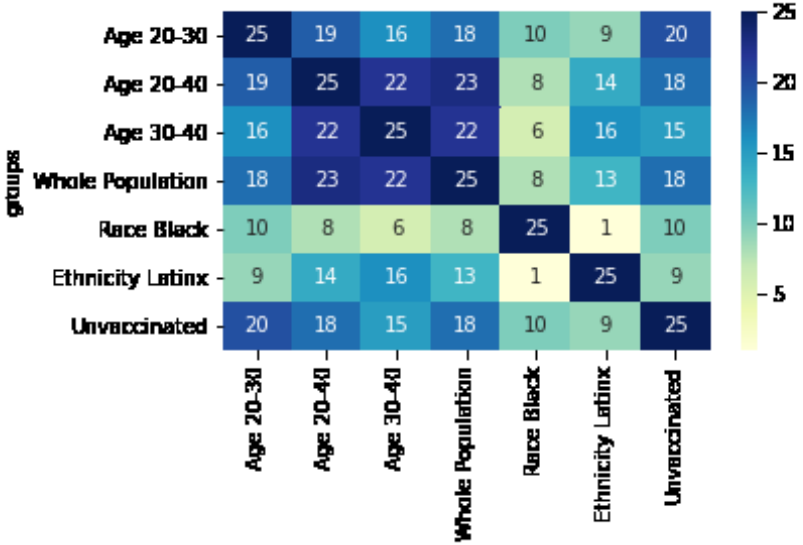
Goal: Provide frequently visited locations based on populations and vaccination levels one desires to reach

Example: List of location in the Southside frequented by 20-40 year olds

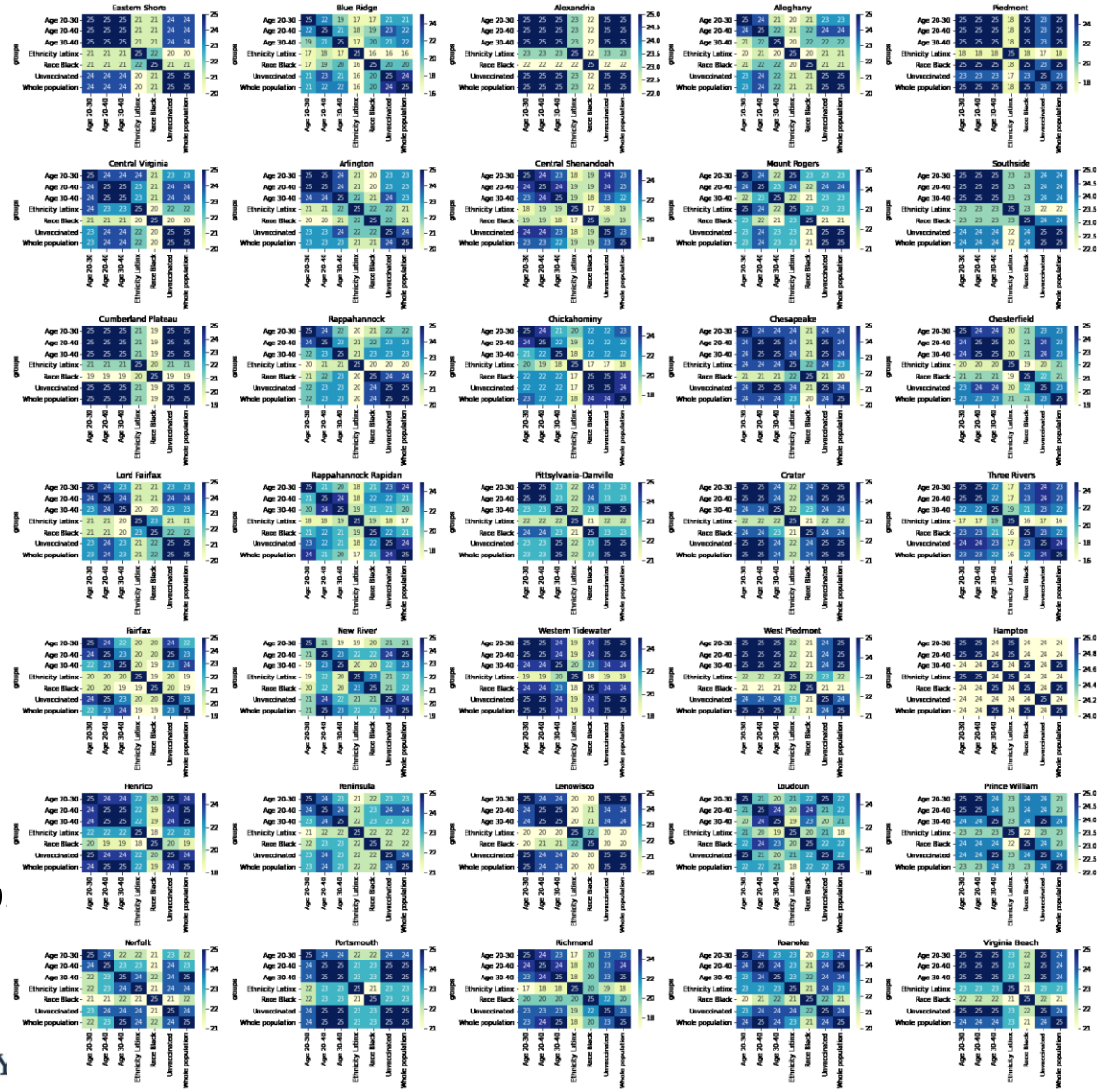
Data Recommended Mobile Vax Clinic Sites

Overlap of locations between groups

State Level



Within VDH Health Districts



Different groups visit different areas

- Least overlap between Black and Latinx
- Overlap in ages highest, but drops with large gap
- Districts have different overlap patterns

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Google. COVID-19 community mobility reports. https://www.google.com/covid19/mobility/

Biocomplexity page for data and other resources related to COVID-19: https://covid19.biocomplexity.virginia.edu/

Questions?

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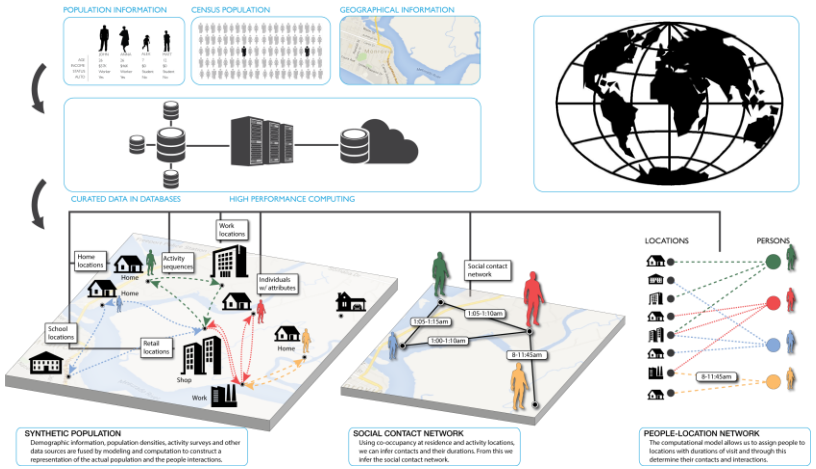
Supplemental Slides

Agent-based Model (ABM)

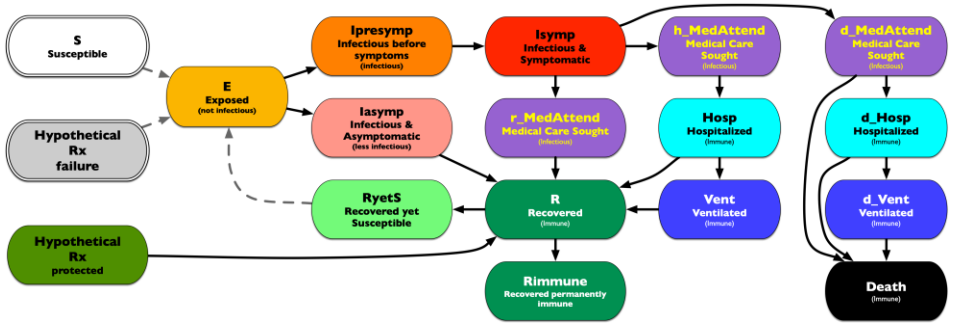
EpiHiper: Distributed network-based stochastic disease transmission simulations

- Assess the impact on transmission under different conditions
- Assess the impacts of contact tracing



Synthetic Population

- Census derived age and household structure
- Time-Use survey driven activities at appropriate locations



Detailed Disease Course of COVID-19

- Literature based probabilities of outcomes with appropriate delays
- Varying levels of infectiousness
- Hypothetical treatments for future developments